An Implementation of All Weather Investment Strategy

MMF2025 Risk Analysis

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Agenda

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- **Data Collection**
  - Assets
  - Macro Variables
  - Risk Factors and Benchmark
- **Allocation Strategies**
  - Concepts
  - Results and Selection
- **Portfolio Performance**
- **Risk Management**
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Introduction

- Initial Capital: $100,000 CAD provided on April 1st, 2016
- Injections: $10,000 CAD every 6 months, starting on October 1st, 2016
- Currency requirement: Initial capital, and injections split 50/50 into USD and CAD
- Currency limit: Currency mix between 40/60 – 60/40
- Rebalancing: every six months coincide with injection

Data Collection

- **Assets selection criteria:**
  - A broad range of coverage
  - History of record

	USD	CAD
Equity & Credit:	SPY QQQ VWO EWC EFA VGK IOO LQD	XIU.TO XBB.TO XSP.TO XIN.TO
Government Bond	SHY IEF	XGB.TO
Inflation linked Bond:	TIP	XRB.TO
Real Estate, Commodities	IYR	XRE.TO

Data Collection

•Macroeconomic Data

- U.S. Fed funds
- U.S. CPI
- U.S. GDP
- U.S. Unemployment rate
- CANADA Interest rate
- CANADA GDP
- CANADA CPI
- FX CAD/USD

Data Collection

- **Fama-French factors**
  - **Rm-Rf**: the difference between the return on the value-weight (VW) market portfolio and risk-free rate.
  - **SMB**: the return on a diversified portfolio of small stocks minus the return on a diversified portfolio of big stocks.
  - **HML**: the difference between the returns on diversified portfolios of high and low B/M stocks.
  - **RMW**: the difference between the returns on diversified portfolios of stocks with robust and weak profitability
  - **CMA**: the difference between the returns on diversified portfolios of low and high investment stocks (conservative and aggressive).
- **Benchmark**
  - Barclay Fund of Funds Index

Allocation Strategy

- Equal Weight (EW)
- Minimum Variance (MV)
- All weather (AW)
- Naive Risk Parity (NR)
- Risk Parity (RP)
- Maximum Sharpe Ratio (MS)
- Trend Following (TF)

Concepts

- Equal weight (EW): Distributing wealth equally among assets, also known as the ‘1/n’ portfolio.

- Minimum Variance (MV): Invest the portfolio with the minimum variance possible for a given set of assets, which means we trying to minimize the uncertainty.

- All weather (AW): combine the MV and all-weather concept, with a upper and lower bound for each class of assets to ensure diversification.

All-weather Concepts

- Components:

		Inflation	
		Low	High
Growth	Low	**Deflation:** Nominal Bonds	**Stagflation:** Inflation-linked Bonds
	High	**Growth and Prosperity:** Equity, Credit	**Inflation:** Real Assets, Commodities

- Purpose: to achieve relatively reasonable return during both bear and bull market through diversification.

Concepts

- Naive Risk parity (NR): Weight is determined by the inverse of their standard deviation divided by the sum of the inverses.

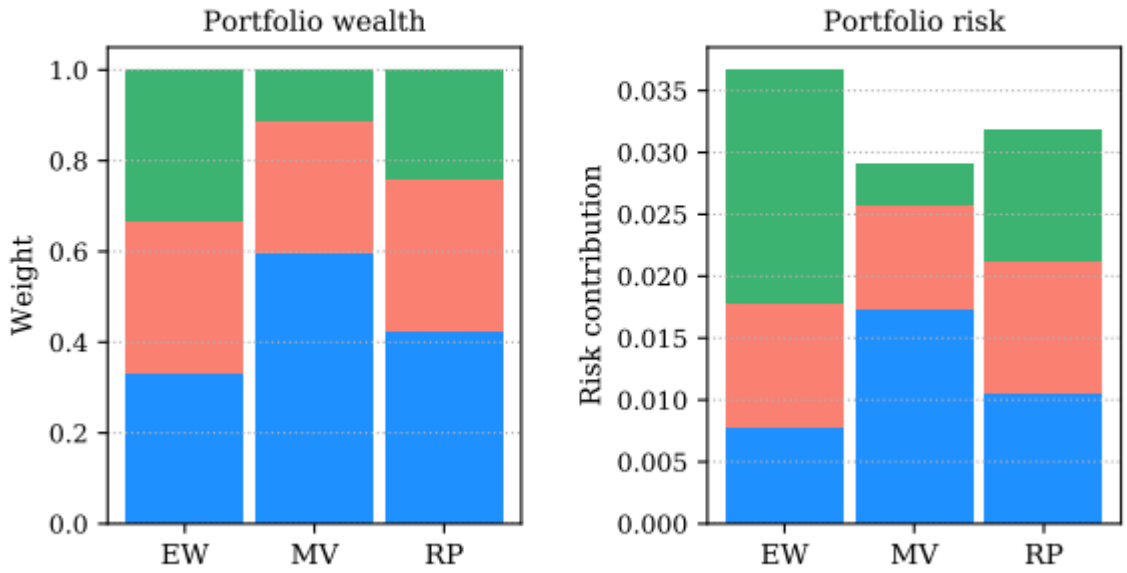
- Risk parity (RP): The goal of this strategy is to equalize the risk contribution per asset. By minimizing the difference in risk contributions per asset, we have the Risk parity portfolio.

- Maximum Sharpe Ratio (MS): Tilting weight towards higher Sharpe Ratio assets during the calibration period. Sharpe Ratio measures the performance of a portforlio comparing to a risk-free asset, after adjusting for its risk.

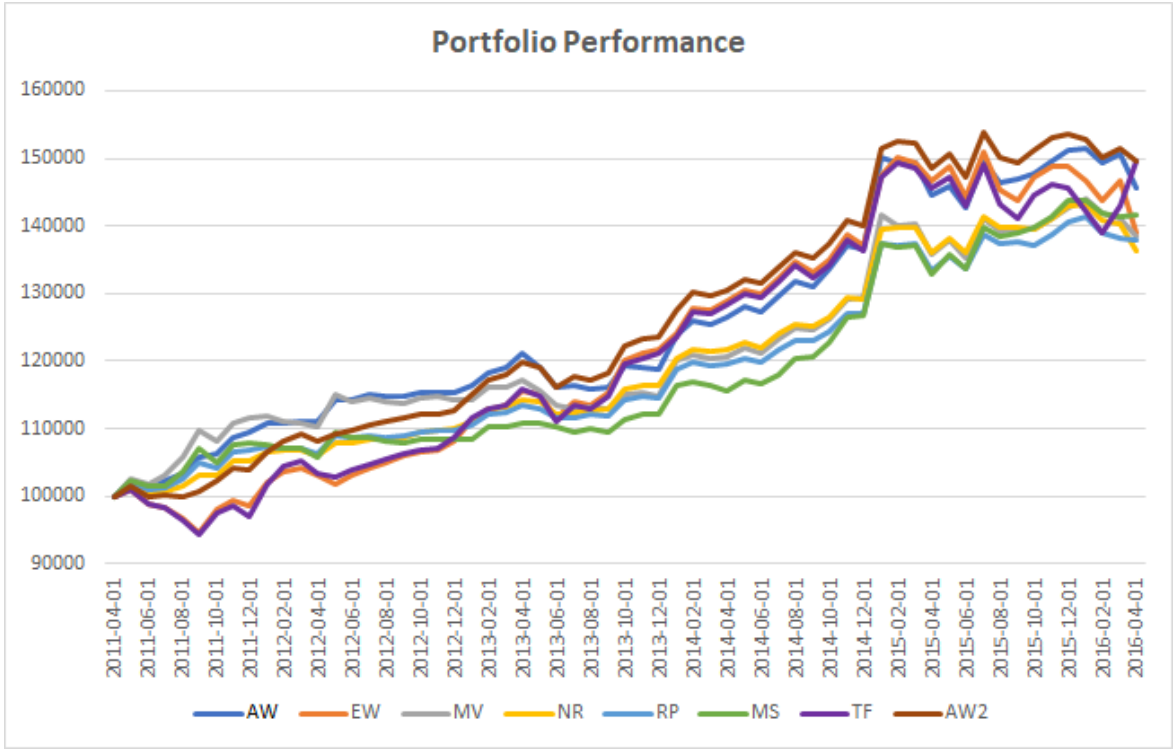
- Trend Following (TF): Try to catch market momentum by investing more in assets that are rising and less that are falling.

Comparison of different strategy

$$\sigma_{MV} \leq \sigma_{RP} \leq \sigma_{EW}$$

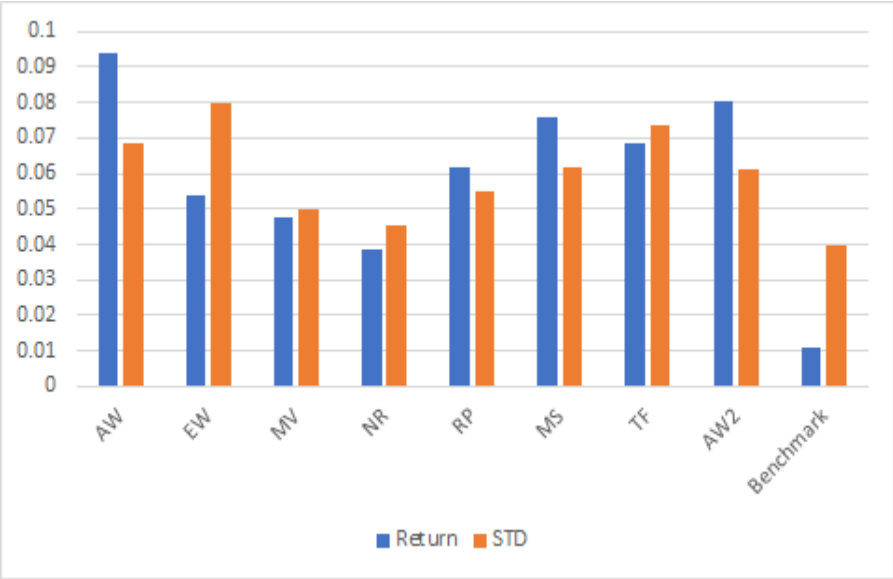


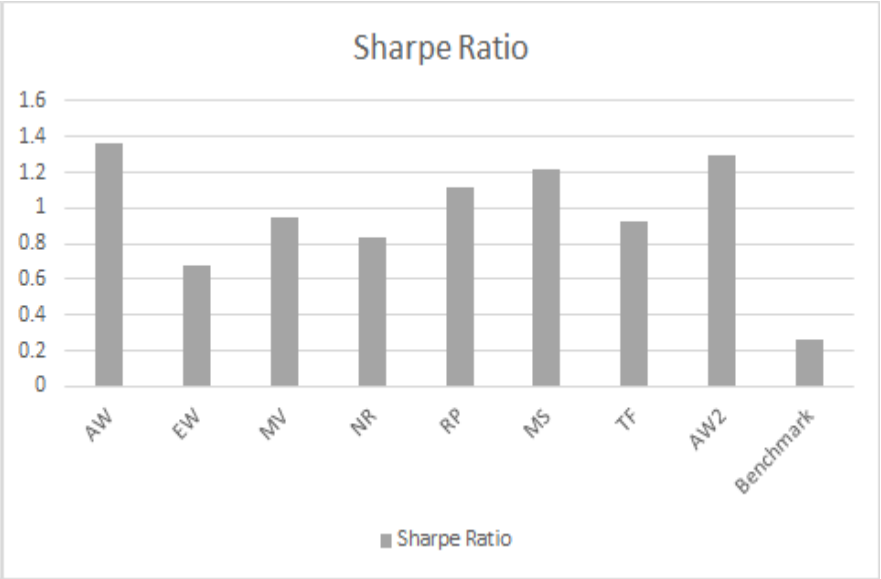
Strategy Selection



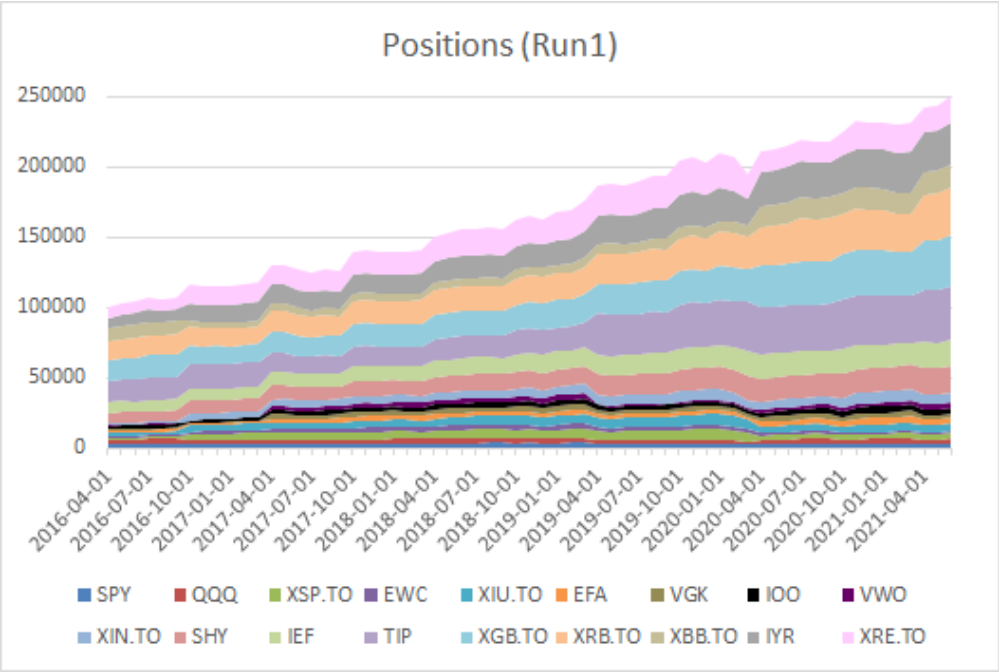
Strategy Selection

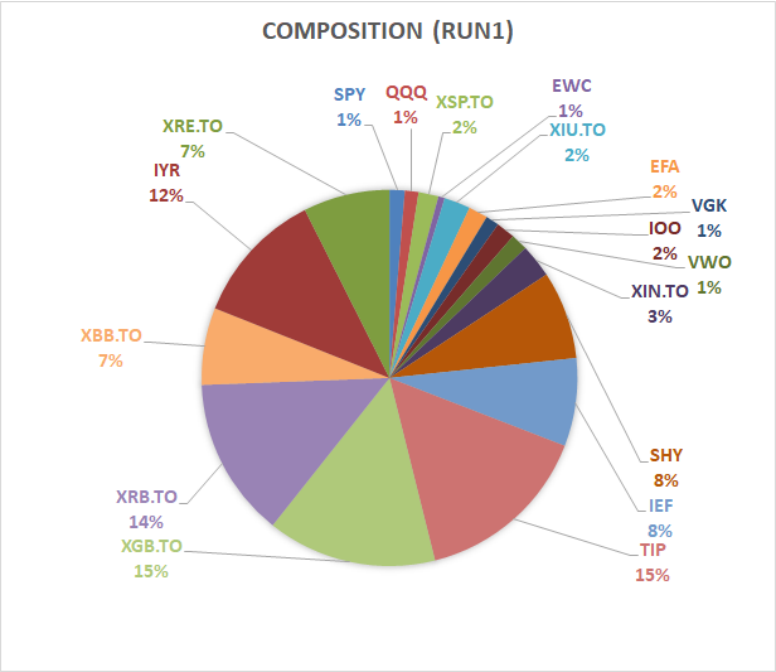
- We selected the strategy that gave the highest Sharpe Ratio, which is Minimum Variance optimization for All-weather.





Portfolio Performence





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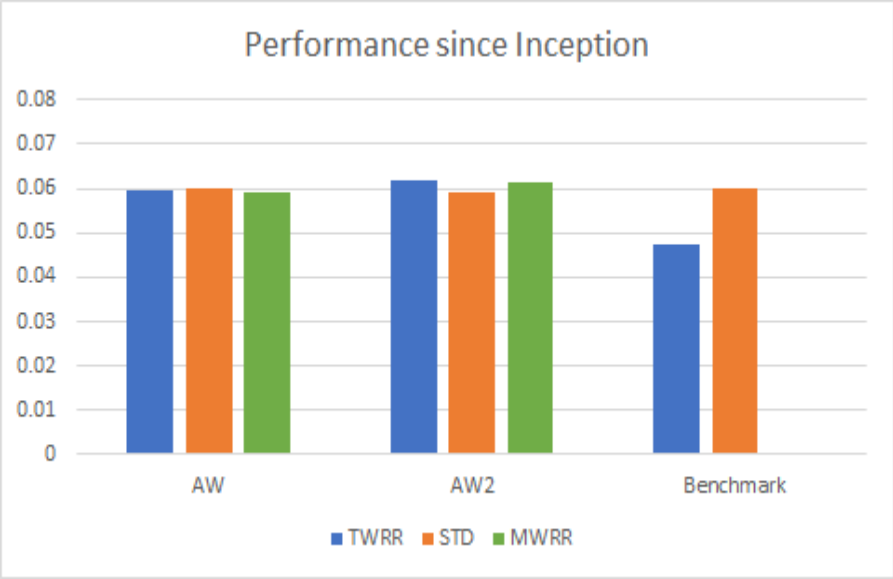
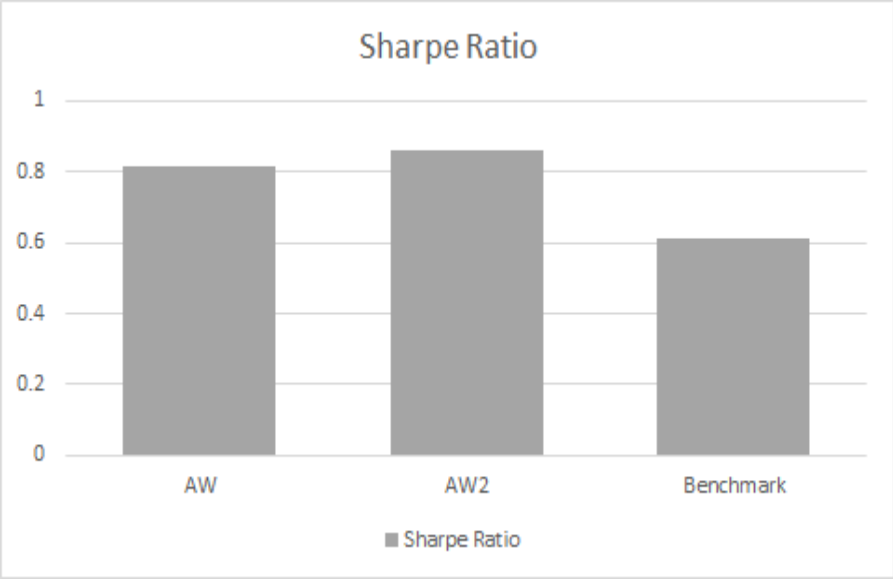
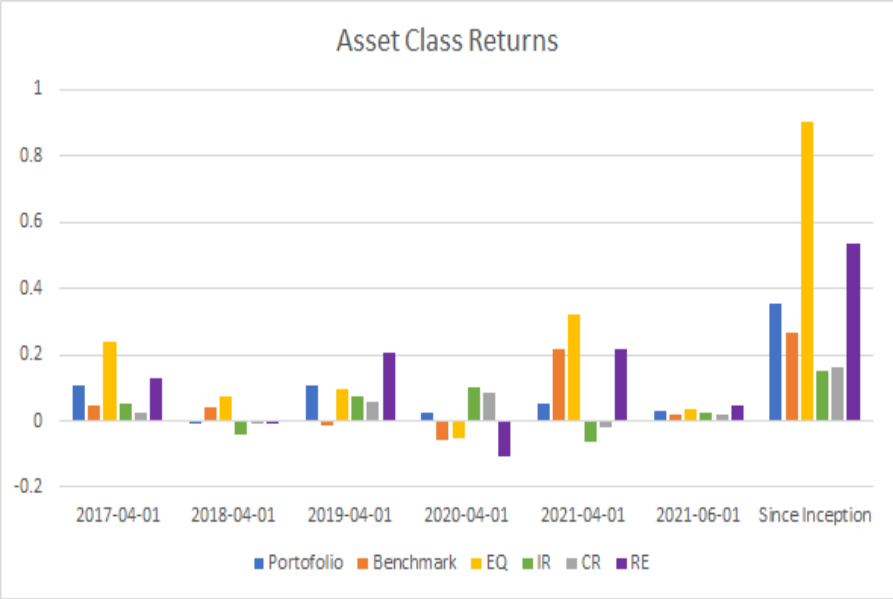
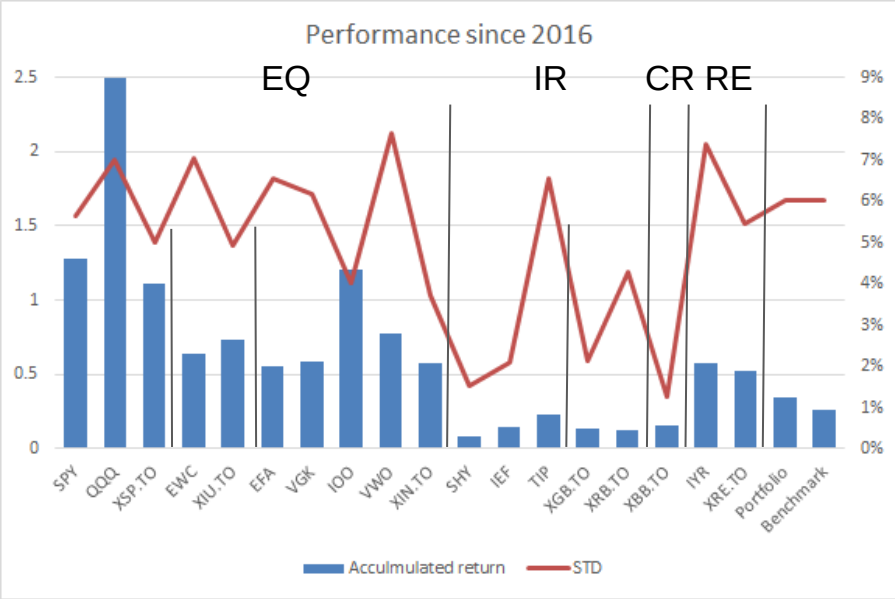




Portfolio Performence

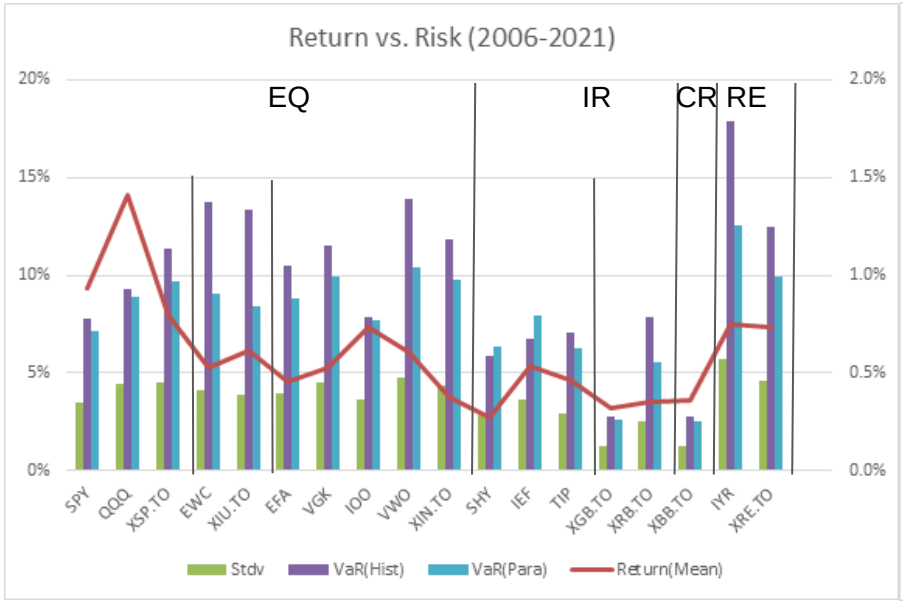


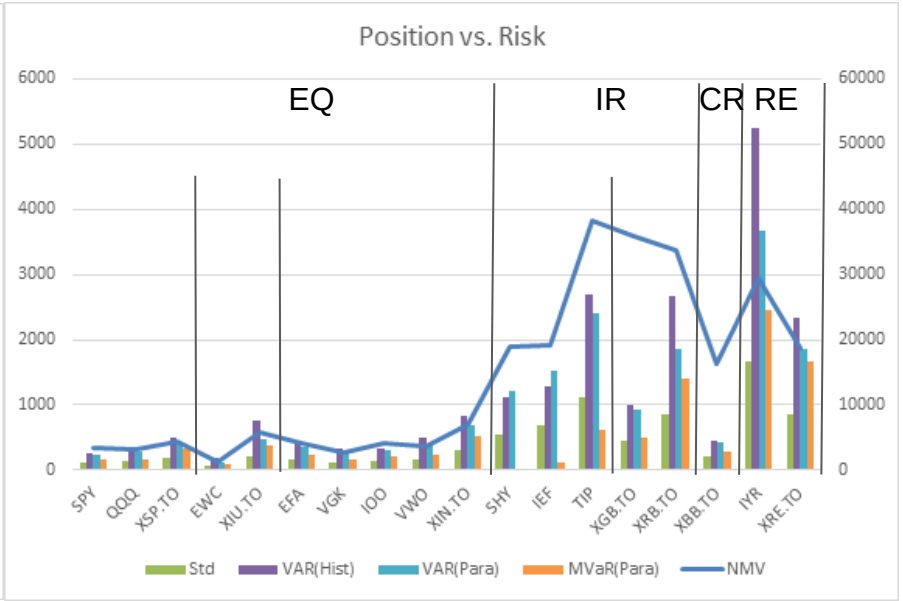


Risk Management

- VaR Analysis
- Scenario Testing

VaR Analysis





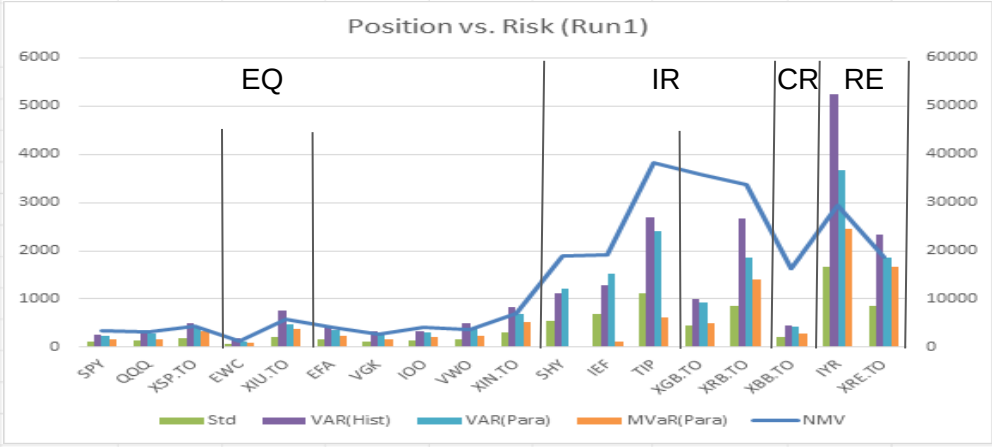
VaR Analysis Dashboard (Run1)

$ CAD (thousand)	NMV	VaR	VaR (Marginal)
Portfolio	249.797	10.669	10.669
EQ	39.346	4.294	2.822
IR	146.059	5.743	2.925
CR	16.329	0.455	0.316
RE	48.062	4.602	4.606

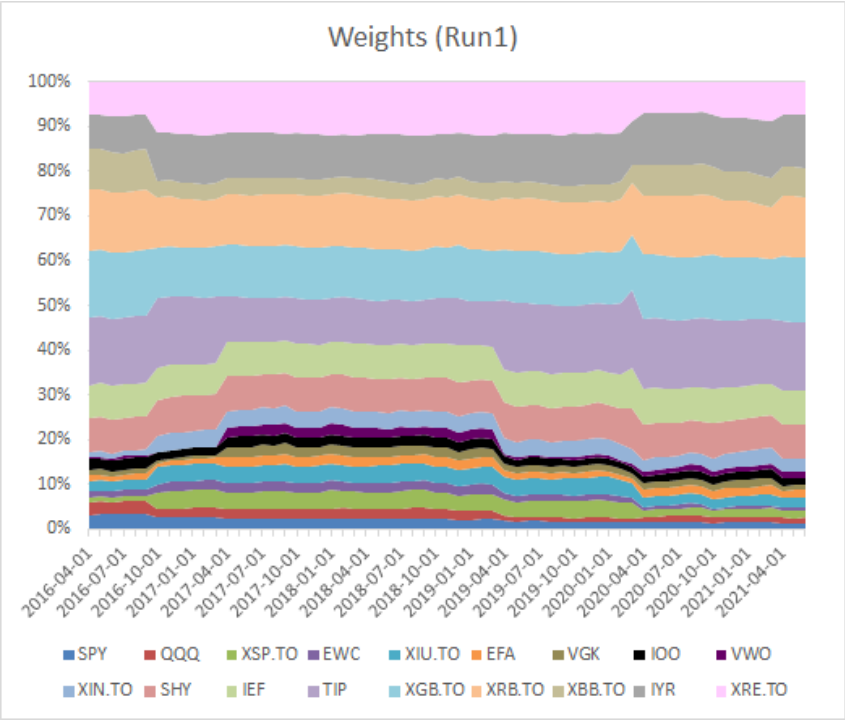
NMV	US	CA	INT	Total
EQ	4%	3%	9%	16%
IR	31%	28%		58%
CR		7%		7%
RE	12%	8%		19%
Total	47%	45%	9%	100%

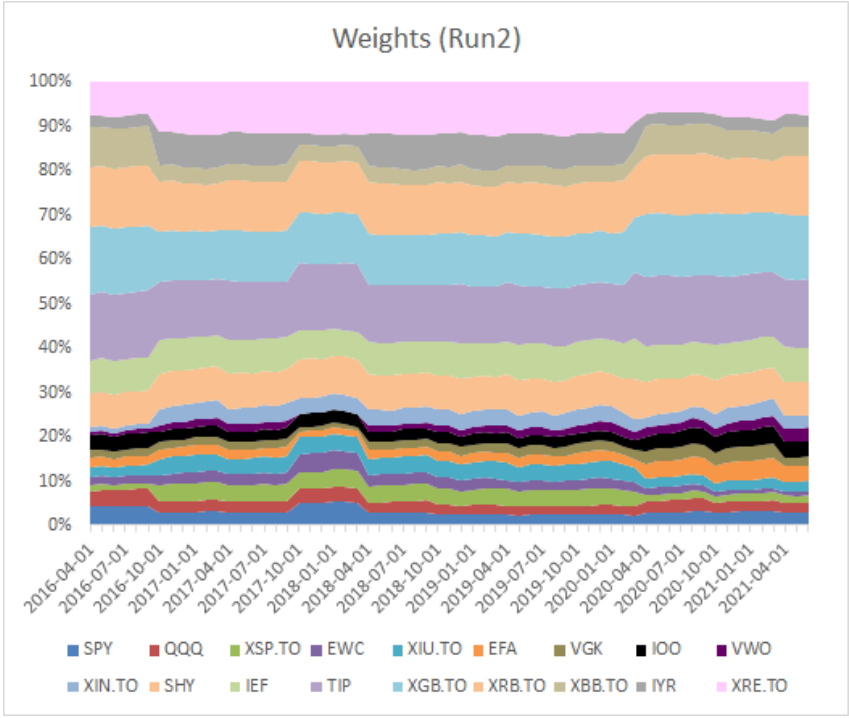
VaR (Marginal)	US	CA	INT	Total
EQ	7%	5%	14%	26%
IR	8%	20%		27%
CR		3%		3%
RE	26%	17%		43%
Total	40%	45%	14%	100%

Porfolio (thousand)	249.797	10.669	10.669
EQ	39.346	4.294	2.822
US-EQ	10.730	0.947	0.754
CA-EQ	7.039	0.946	0.524
INT-EQ	21.577	2.306	1.544
IR	146.059	5.743	2.925
US-IR	76.331	5.326	0.809
CA-IR	69.729	3.058	2.116
CR	16.329	0.455	0.316
CA-CR	16.329	0.455	0.316
RE	48.062	4.602	4.606
US-RE	29.327	5.238	2.749
CA-RE	18.735	2.333	1.857



Exposure Reduction





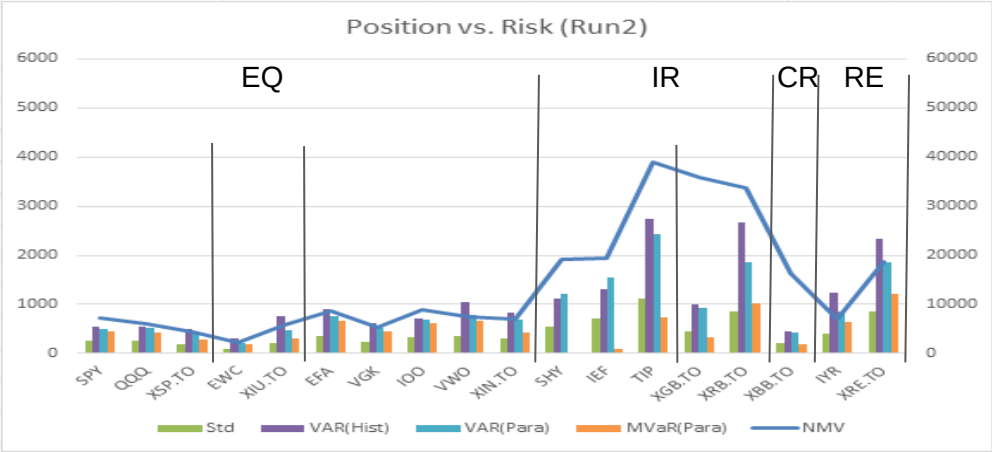
VaR Analysis Dashboard (Run2)

$ CAD (thousand)	NMV	VaR	VaR (Marginal)
Portfolio	251.965	8.489	8.489
EQ	62.636	6.330	4.370
IR	147.387	5.785	2.124
CR	16.329	0.455	0.189
RE	25.613	1.652	1.806

NMV	US	CA	INT	Total
EQ	7%	3%	15%	25%
IR	31%	28%		58%
CR		6%		6%
RE	3%	7%		10%
Total	40%	45%	15%	100%

VaR (Marginal)	US	CA	INT	Total
EQ	13%	6%	32%	51%
IR	10%	15%		25%
CR		2%		2%
RE	7%	14%		21%
Total	30%	37%	32%	100%

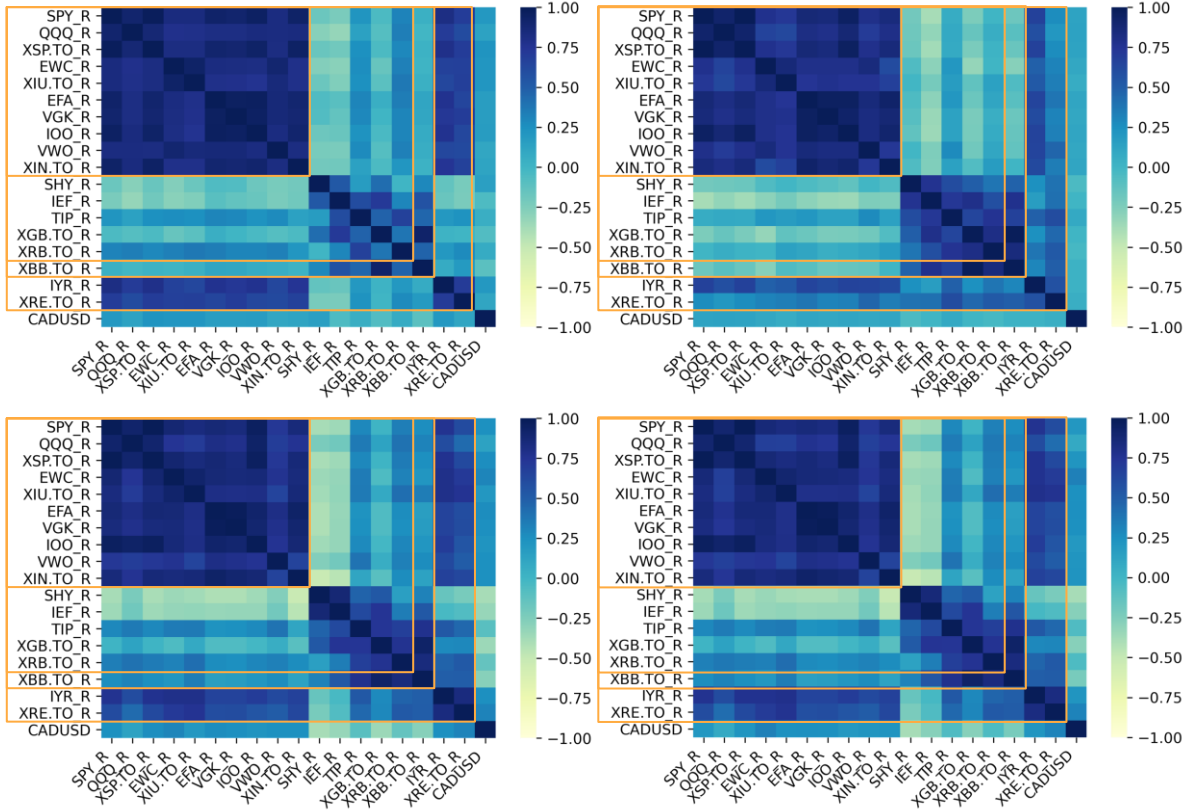
Porfolio (thousand)	251.965	8.489	8.489
EQ	62.636	6.330	4.370
US-EQ	17.333	1.355	1.132
CA-EQ	7.900	1.064	0.487
INT-EQ	37.403	3.778	2.751
IR	147.387	5.785	2.124
US-IR	77.659	5.419	0.811
CA-IR	69.729	3.058	1.314
CR	16.329	0.455	0.189
CA-CR	16.329	0.455	0.189
RE	25.613	1.652	1.806
US-RE	6.877	1.228	0.624
CA-RE	18.735	2.333	1.182



Model Risk

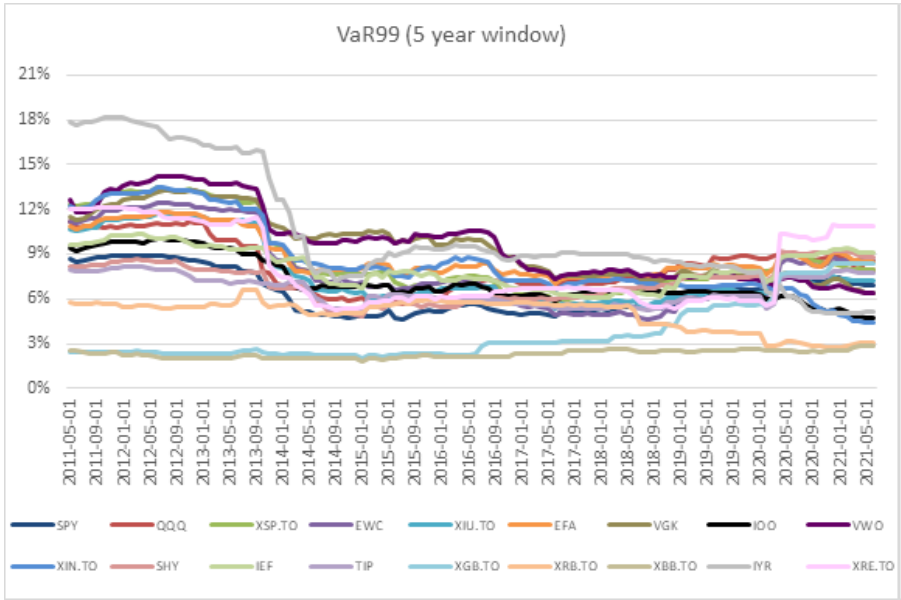
Correlation heatmap

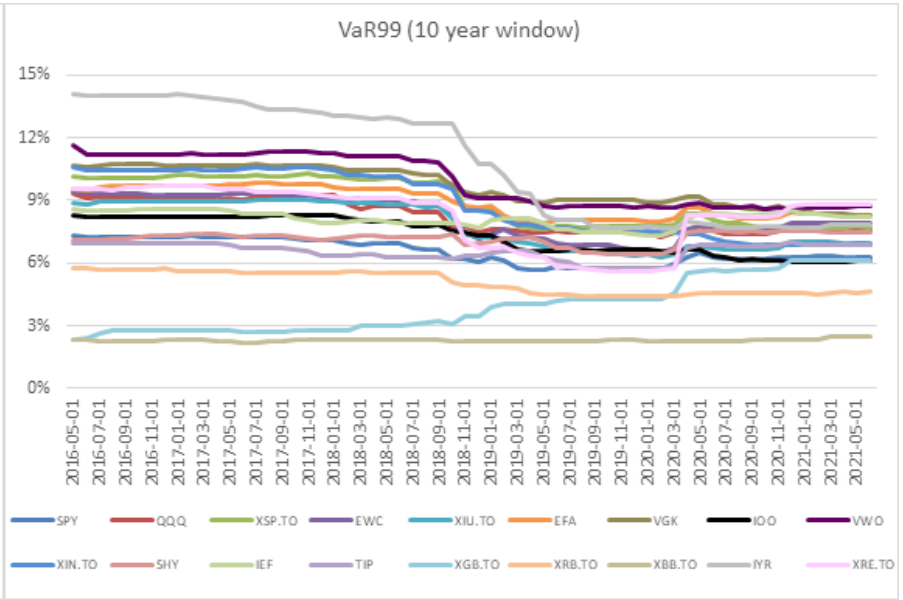
1. 2006/4 - 2011/4
2. 2011/4 - 2016/4
3. 2016/4 - 2021/6
4. 2006/4 - 2021/6



Model Risk

VaR99





Scenarios Testing

1. Historical Scenarios:

- Crises, growth, smart searches for specific periods or characteristics.

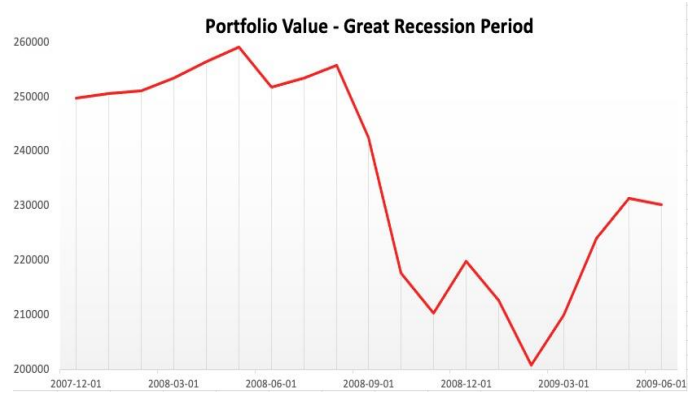
2. Hypothetical Scenarios:

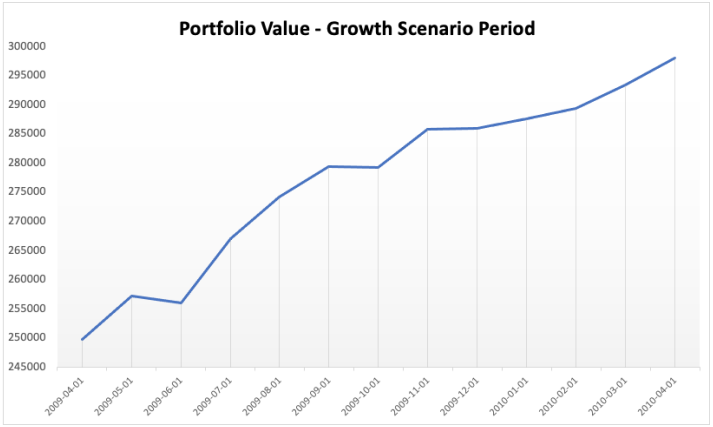
- the process of evaluating the impact of specified scenarios on a portfolio in the future.

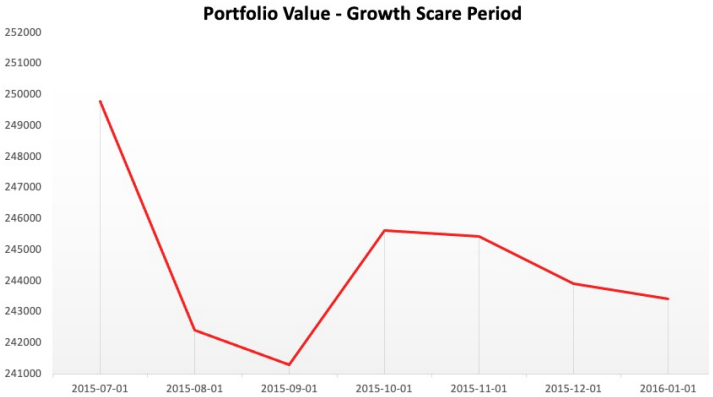
Example: Historical Scenarios

Scenarios	Start Date	End Date	Duration (Months)
Great Recession	December 2007	June 2009	19
2009-2010 Growth Scenario	March 2009	April 2010	14
2015-2016 Growth Scare	July 2015	January 2016	7
Covid-19 Period	February 2020	June 2021	17

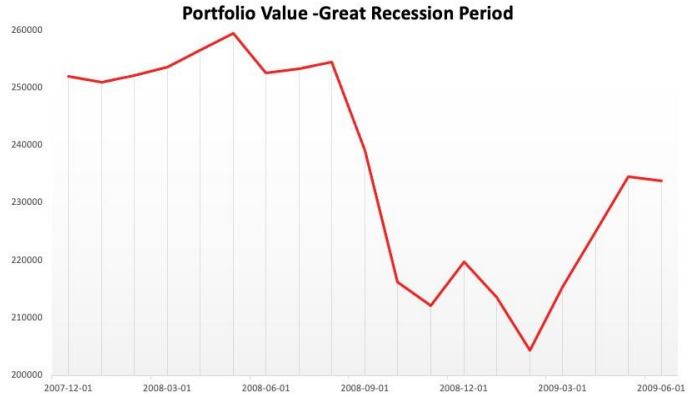
Four Examples of Historical Scenarios - Run 1

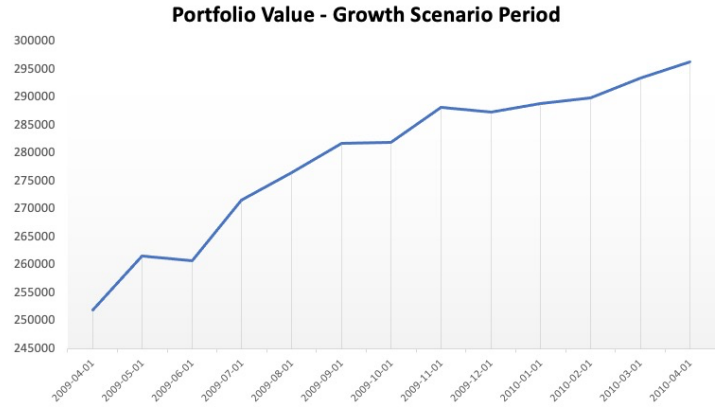


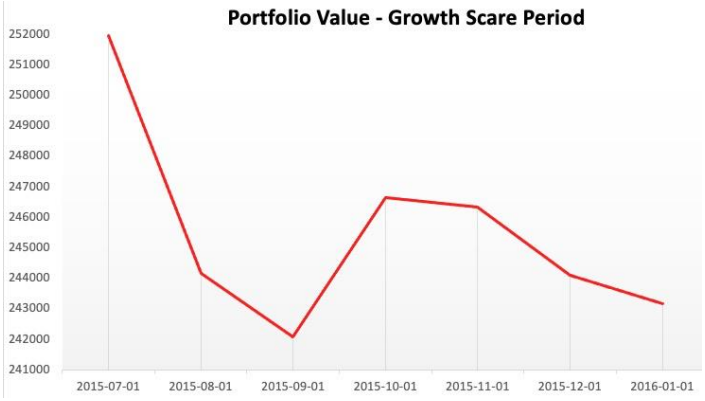


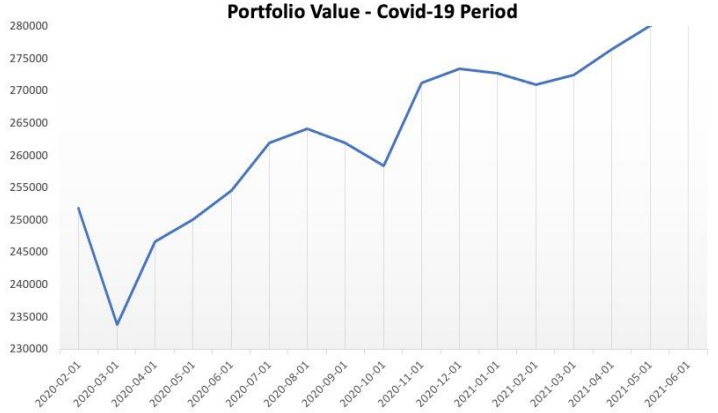


Four Examples of Historical Scenarios - Run 2









Hypothetical Scenarios

Global Scenario (base case):

- Use VAR Model to forecast the next 4 quarters for macro data.
- Regress historical macro and factor data, then forecasted factor in the next 4 quarters will be obtained.
- Regress historical factor and asset data, then forecasted asset data and portfolio value will be obtained.

Upside case

- Increase US GDP rate by one standard deviation, increase inflation to 2%, increase market risk premium by 6%.

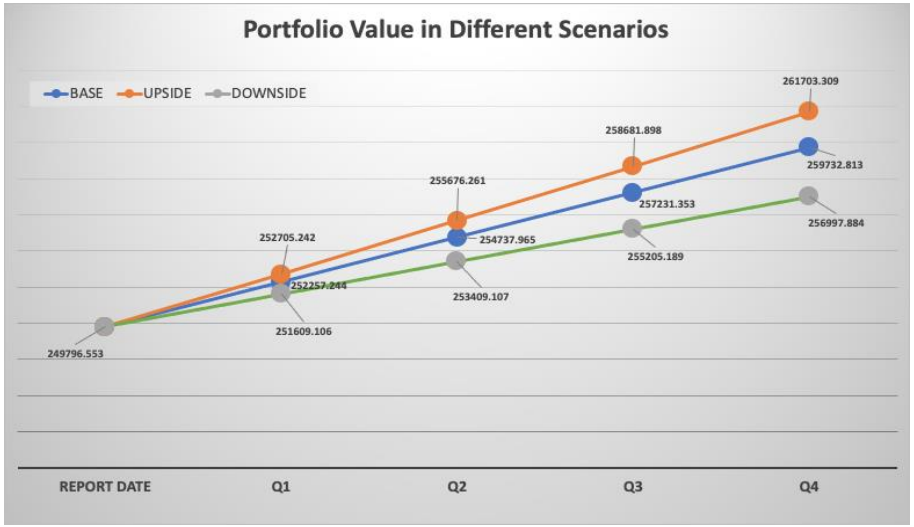
Downside case:

- Decrease US GDP rate decreases by one standard deviation, increase US unemployment rate by one standard deviation, decrease US/CAD FX by one standard deviation, decrease market risk premium by 10%.

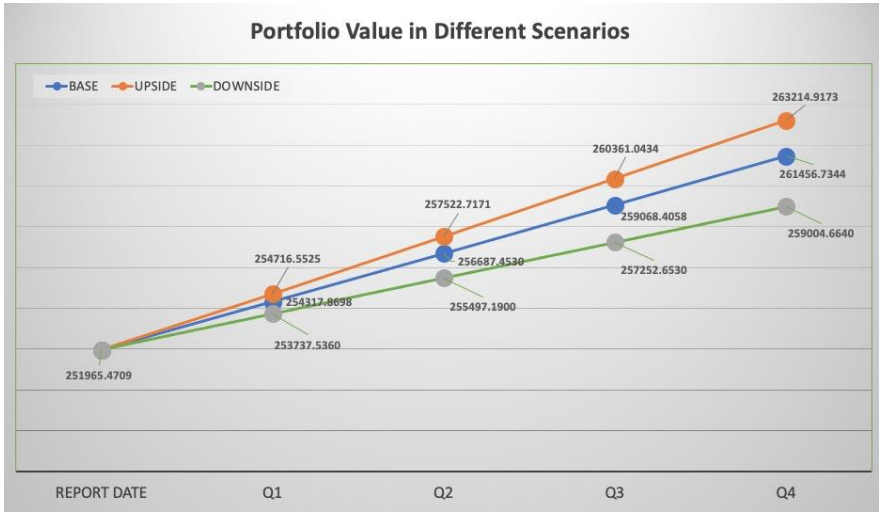
	UPSIDE	BASE	DOWNSIDE
Real GDP (%)	0.503	0.491	0.479
Inflation (%)	2	0.365	0.365
Unemployment (%)	5.987	5.987	7.718
USD/CAD FX	1.258	1.258	1.091
Market Risk Premium	1.086	1.026	0.926

Economic Scenarios – Model Mapping

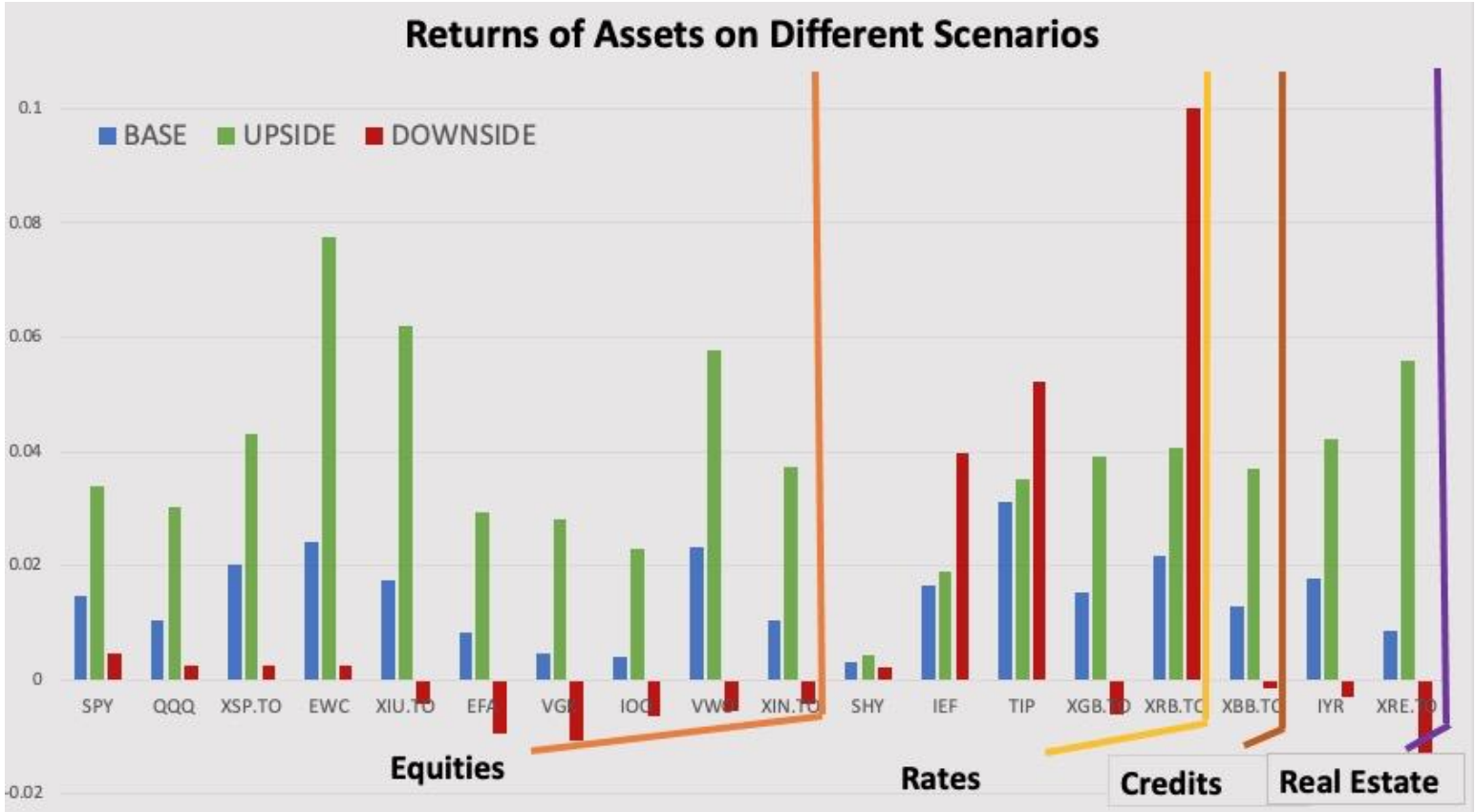
Run 1



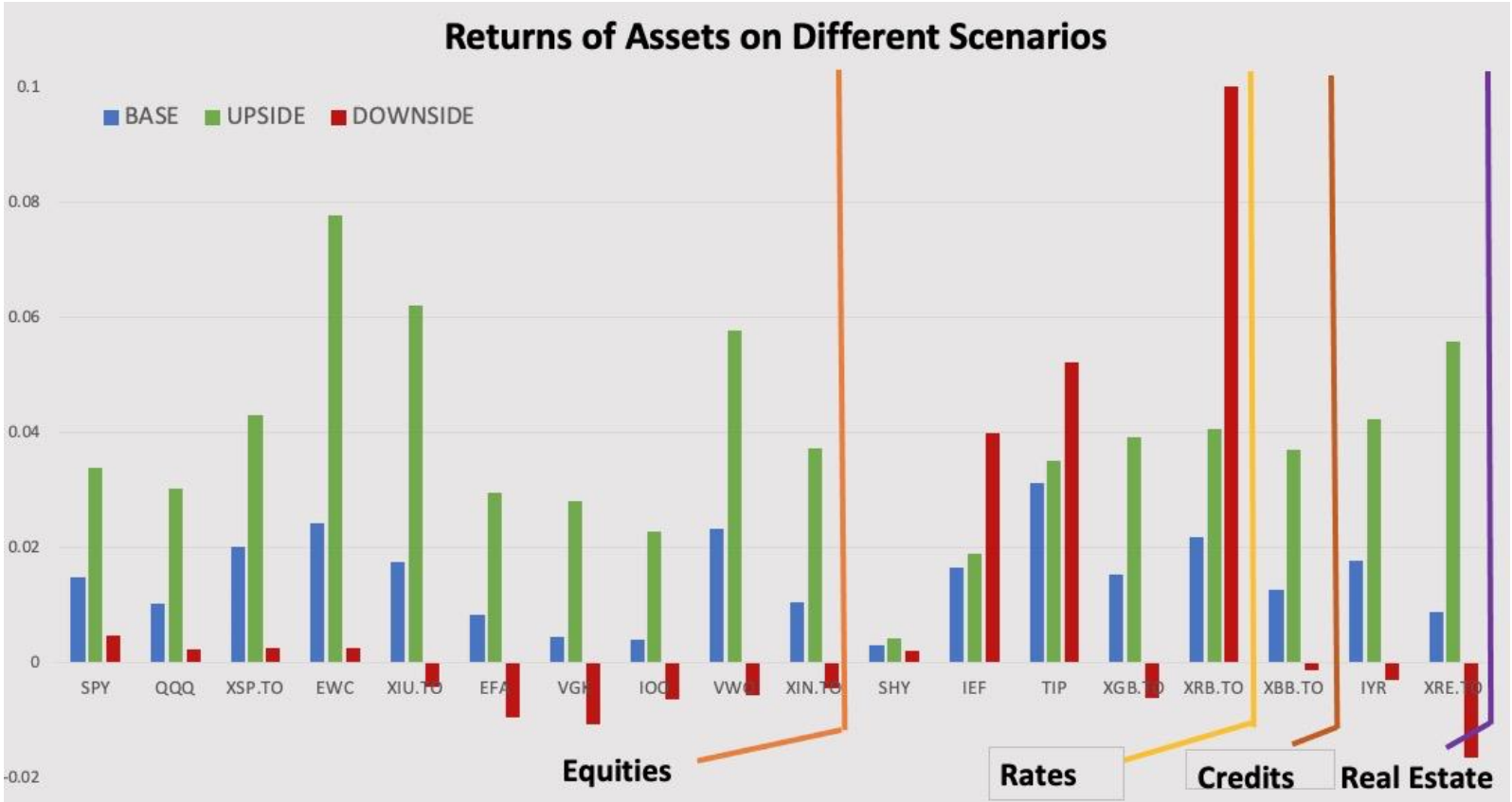
Run 2



Conditional Expected Scenarios on Market Factors - Run 1



Conditional Expected Scenarios on Market Factors - Run 2

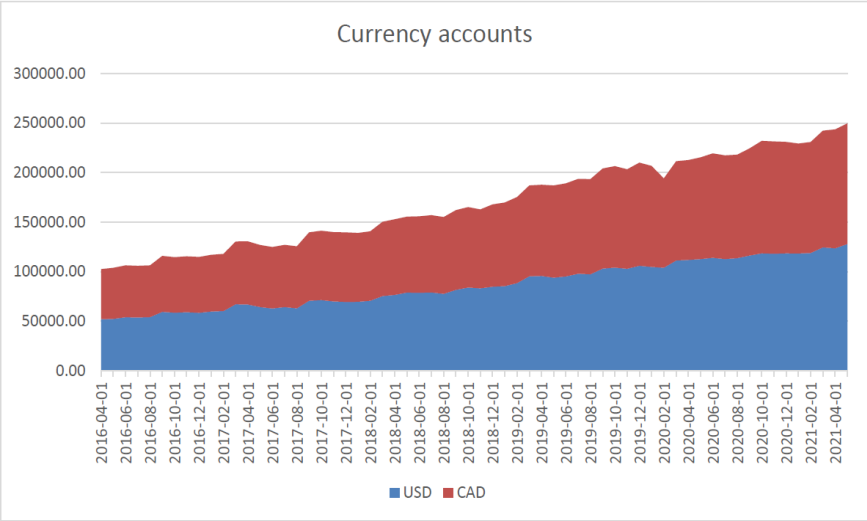


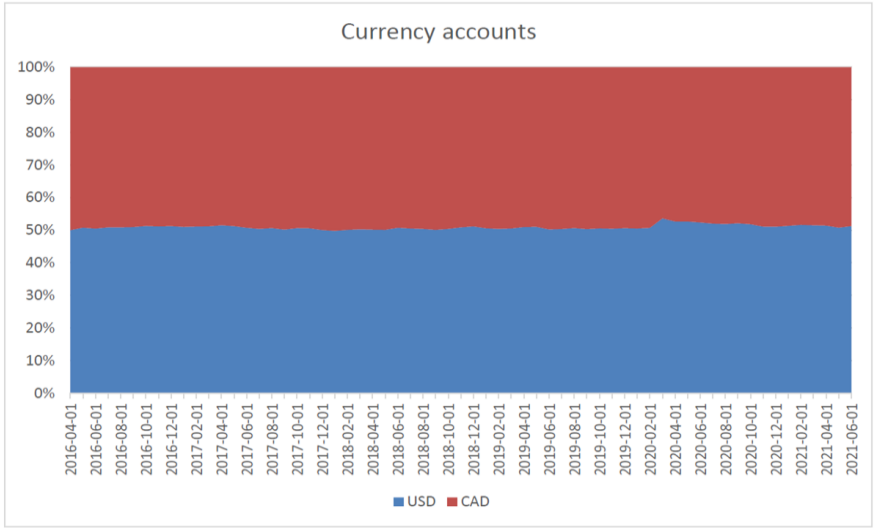
Conclusion

- A broader asset universe will allow us to explore more investment options and further to diversify our portfolio.
- Our strategies and risk metrics are variance-covariance based and rely on parameter stability, which is subject to model risk.
- Could incorporate other information such as variables that have predictability or professional judgements into our strategies.
- Given more autonomy to tilte weights based on these information can improve performance.
- VaR analysis is backward looking and thus scenario analysis are necessary.
- Fund of funds benchmark index is inappropriate and we will construct our own benchmark in the future.

Appendix

Currency mix



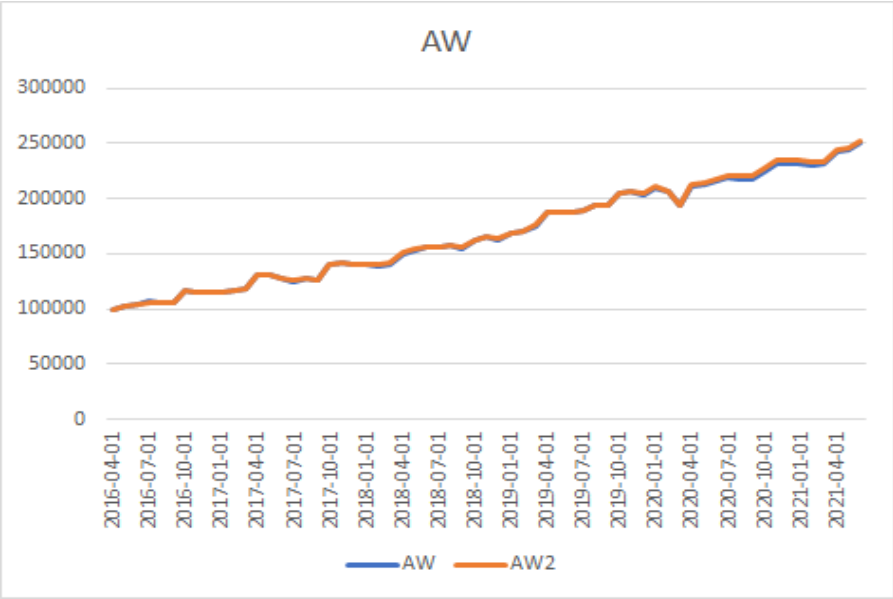


Appendix

Performance analysis

	AW	AW2	Benchmark
TWRR	0.059554197	0.061707	0.047187
MWRR	0.059082308	0.0614	
excess mean	0.049080164	0.051233	0.036713
Std	0.060205699	0.059377	0.060109
Sharpe Ratio	0.815207942	0.862834	0.610776

Appendix


AW
300000
250000
200000
150000
100000
50000
0
2016-04-01
2016-07-01
2016-10-01
2017-01-01
2017-04-01
2017-07-01
2017-10-01
2018-01-01
2018-04-01
2018-07-01
2018-10-01
2019-01-01
2019-04-01
2019-07-01
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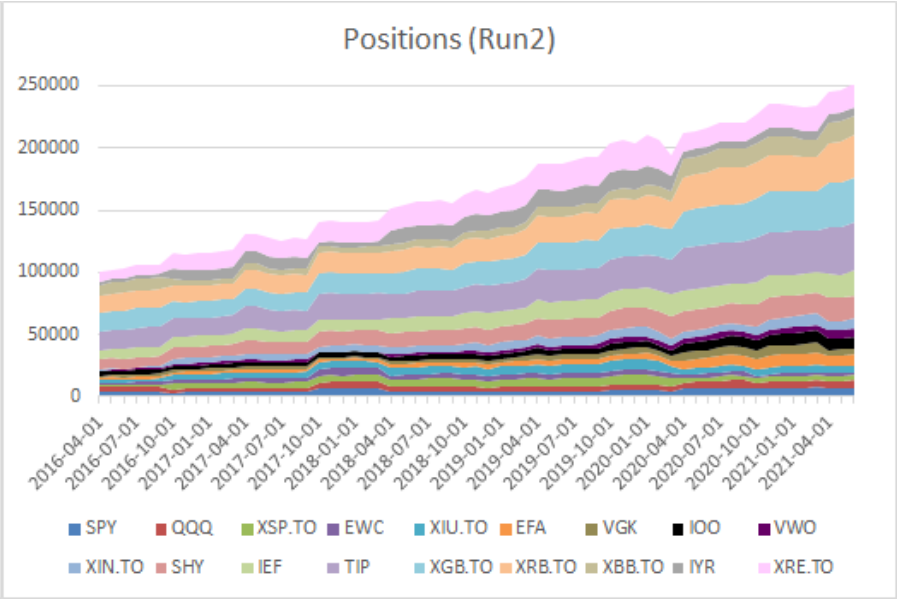
2020-10-01
2021-01-01
2021-04-01
AW
AW2


Positions (Run2)
250000
200000
150000
100000
50000
0
2016-04-01
2016-07-01
2016-10-01
2017-01-01
2017-04-01
2017-07-01
2017-10-01
2018-01-01
2018-04-01
2018-07-01
2018-10-01
2019-01-01
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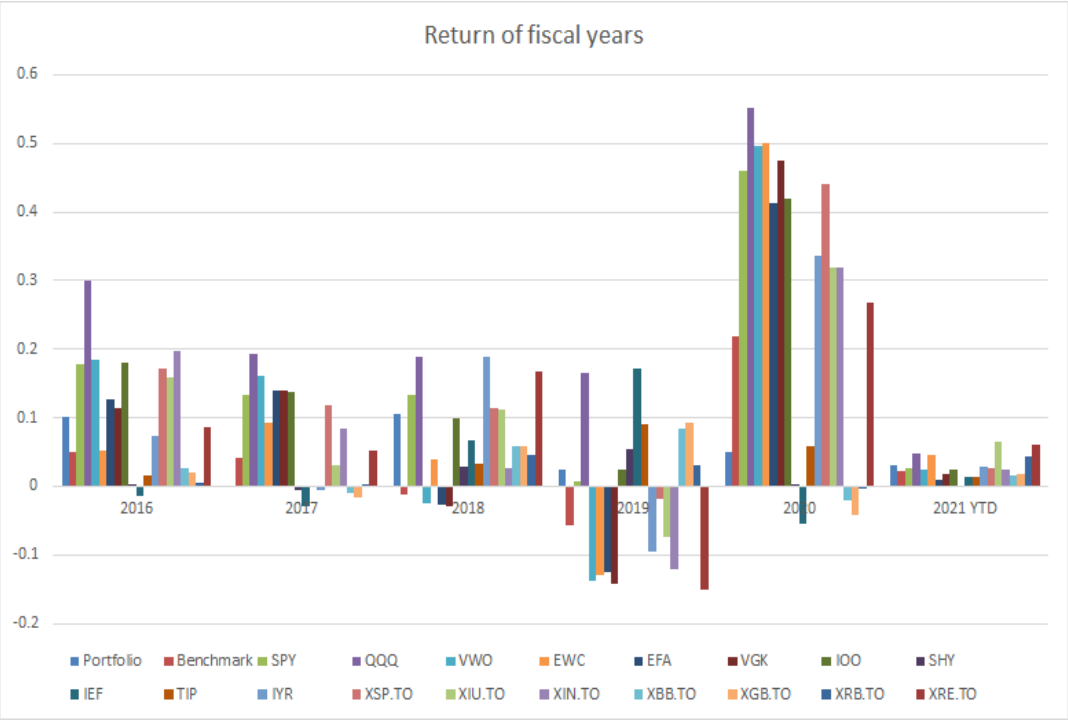
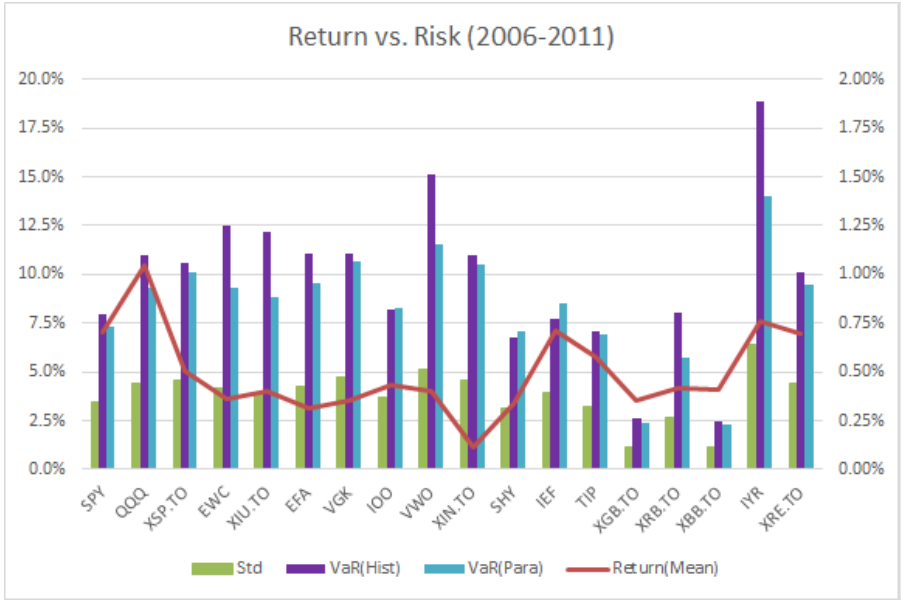
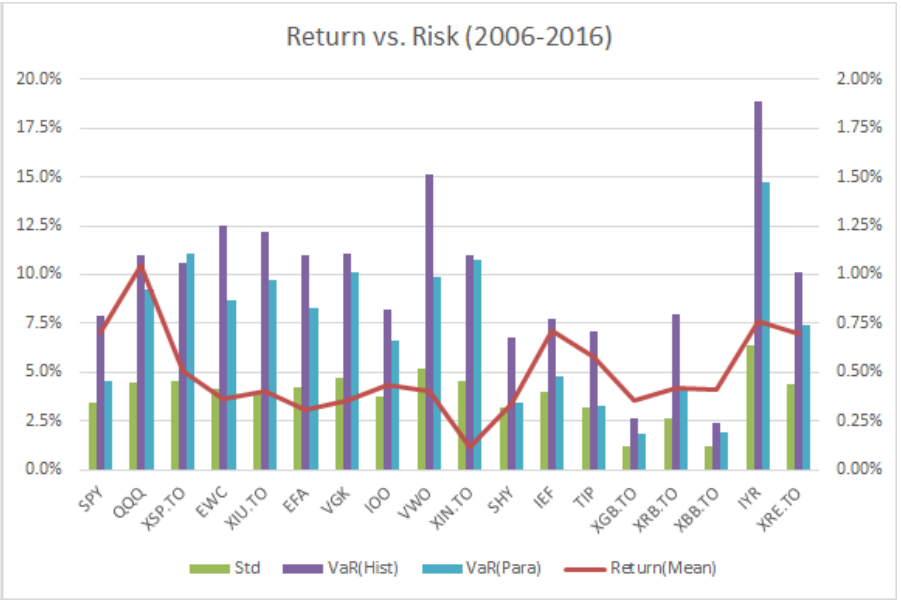
2019-07-01
2019-10-01
2020-01-01
2020-04-01
2020-07-01
2020-10-01
2021-01-01
2021-04-01
SPY
QQQ
XSP.TO
EWC
XIU.TO
EFA
VGK
IOO
VWO
XIN.TO
SHY
IEF
TIP
XGB.TO
XRB.TO
XBB.TO
IYR
XRE.TO

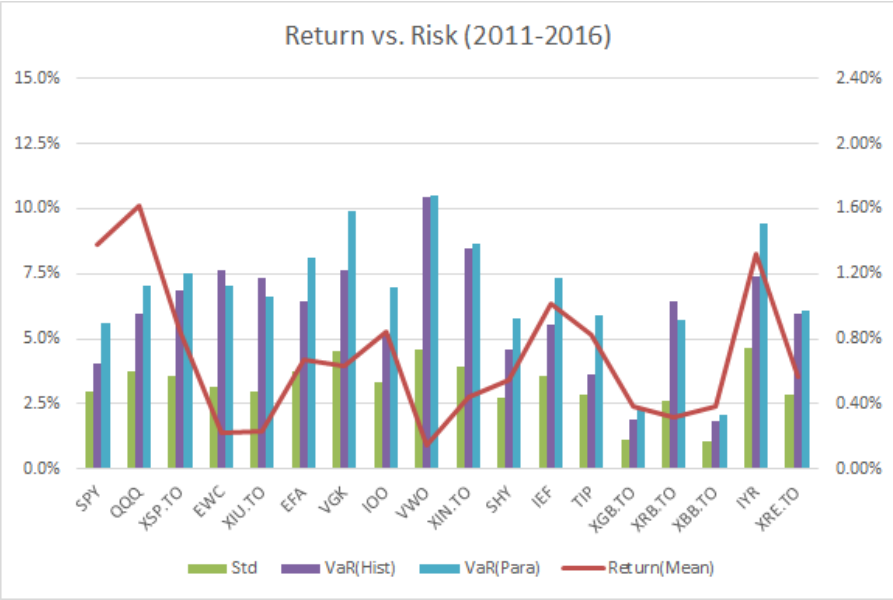
Appendix

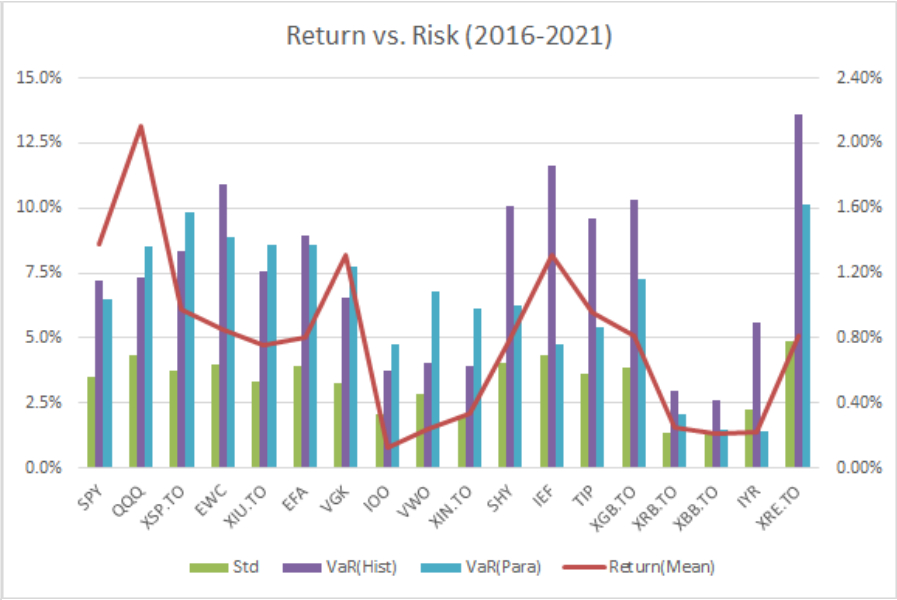

Return of fiscal years
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
2016
2017
2018
2019
2020
2021 YTD
Portfolio
Benchmark
SPY
QQQ
VWO
EWC
EFA
VGK
IOO
SHY
IEF
TIP
IYR
XSP.TO
XIU.TO
XIN.TO
XBB.TO
XGB.TO
XRB.TO
XRE.TO


Return vs. Risk (2006-2011)
20.0%
17.5%
15.0%
12.5%
10.0%
7.5%
5.0%
2.5%
0.0%
2.00%
1.75%
1.50%
1.25%
1.00%
0.75%
0.50%
0.25%
0.00%
SPY
QQQ
XSP.TO
EWC
XIU.TO
EFA
VGK
IOO
VWO
XIN.TO
SHY
IEF
TIP
XGB.TO
XRB.TO
XBB.TO
IYR
XRE.TO
Std
VaR(Hist)
VaR(Para)
Return(Mean)

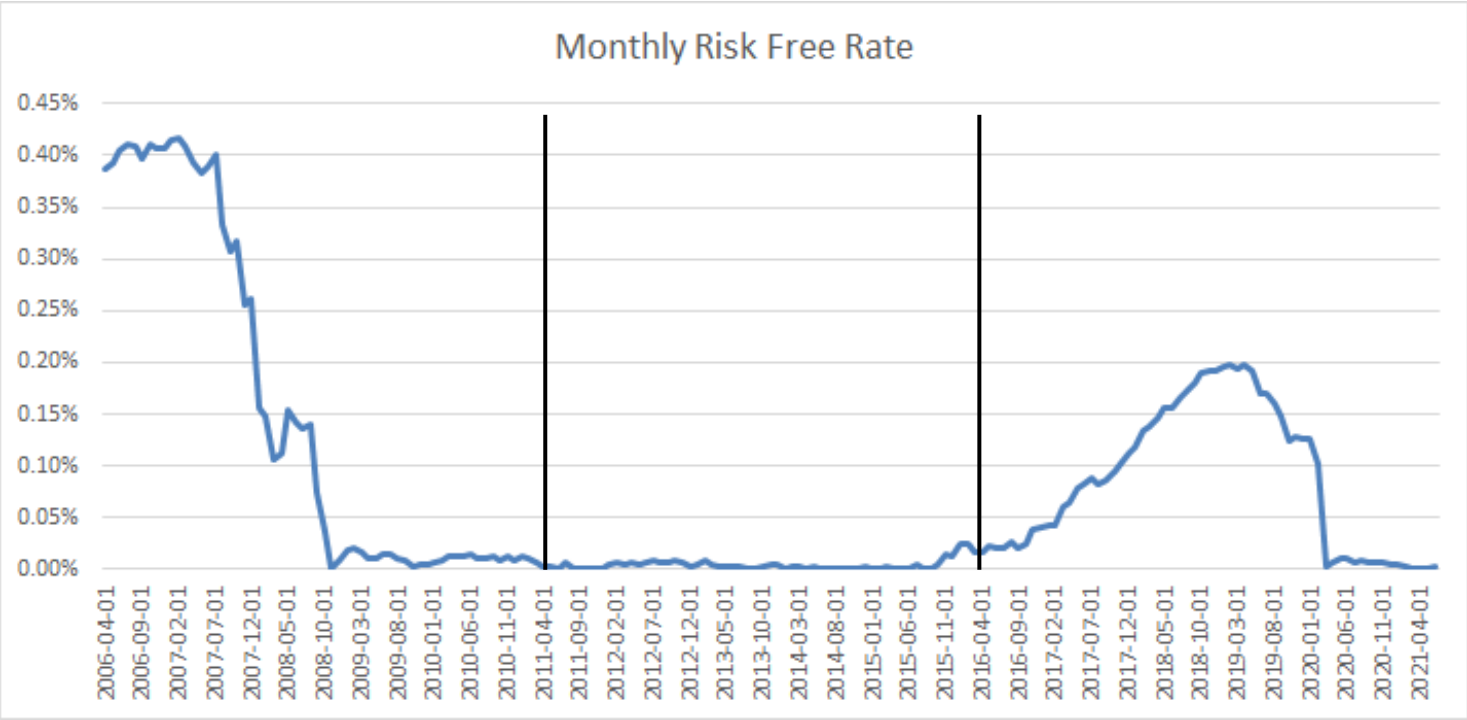

Return vs. Risk (2006-2016)
20.0%
17.5%
15.0%
12.5%
10.0%
7.5%
5.0%
2.5%
0.0%
2.00%
1.75%
1.50%
1.25%
1.00%
0.75%
0.50%
0.25%
0.00%
SPY
QQQ
XSP.TO
EWC
XIU.TO
EFA
VGK
IOO
VWO
XIN.TO
SHY
IEF
TIP
XGB.TO
XRB.TO
XBB.TO
IYR
XRE.TO
Std
VaR(Hist)
VaR(Para)
Return(Mean)

Appendix


Return vs. Risk (2011-2016)
15.0%
12.5%
10.0%
7.5%
5.0%
2.5%
0.0%
2.40%
2.00%
1.60%
1.20%
0.80%
0.40%
0.00%
SPY
QQQ
XSP.TO
EWC
XIU.TO
EFA
VGK
IOO
VWO
XIN.TO
SHY
IEF
TIP
XGB.TO
XRB.TO
XBB.TO
IYR
XRE.TO
Std
VaR(Hist)
VaR(Para)
Return(Mean)


Return vs. Risk (2016-2021)
15.0%
12.5%
10.0%
7.5%
5.0%
2.5%
0.0%
2.40%
2.00%
1.60%
1.20%
0.80%
0.40%
0.00%
SPY
QQQ
XSP.TO
EWC
XIU.TO
EFA
VGK
IOO
VWO
XIN.TO
SHY
IEF
TIP
XGB.TO
XRB.TO
XBB.TO
IYR
XRE.TO
Std
VaR(Hist)
VaR(Para)
Return(Mean)

Appendix


Monthly Risk Free Rate
0.45%
0.40%
0.35%
0.30%
0.25%
0.20%
0.15%
0.10%
0.05%
0.00%
2006-04-01
2006-09-01
2007-02-01
2007-07-01
2007-12-01
2008-05-01
2008-10-01
2009-03-01
2009-08-01
2010-01-01
2010-06-01
2010-11-01
2011-04-01
2011-09-01
2012-02-01
2012-07-01
2012-12-01
2013-05-01
2013-10-01
2014-03-01
2014-08-01
2015-01-01
2015-06-01
2015-11-01
2016-04-01
2016-09-01
2017-02-01
2017-07-01
2017-12-01
2018-05-01
2018-10-01
2019-03-01
2019-08-01
2020-01-01
2020-06-01
2020-11-01
2021-04-01

Appendix

Transaction record: Unit of ETF purchased

	SPY	QQQ	VWO	EWC	EFA	VGK	IOO	SHY	IEF	TIP	IYR	XSP.TO	XIU.TO	XIN.TO	XBB.TO	XGB.TO	XRB.TO	XRE.TO
2016-04-01	13.63503	21.03485	9.921933	46.40197	21.22027	21.43067	61.44545	76.08278	58.63015	116.0885	92.82064	57.42327	129.9239	61.81255	332.5375	767.069	595.4475	598.0397
2016-10-01	-2.054	-6.76703	-9.01149	28.68534	-3.35686	-9.67881	-16.525	11.87386	3.579509	10.77532	48.95952	130.3972	92.83736	149.7324	-180.792	-108.804	-45.2105	448.265
2017-04-01	-1.88405	1.855967	57.38214	13.93043	19.68055	33.40741	11.27827	4.845387	12.63722	-32.0478	0.828442	-1.17808	10.04196	-1.01609	18.34726	85.47155	90.64423	39.27828
2017-10-01	0.24501	-0.08479	-0.3355	1.258336	0.400493	0.333095	0.263661	11.04265	8.530747	11.07971	12.45917	0.736488	9.871205	1.53322	16.31661	73.41399	69.51394	91.2163
2018-04-01	0.260847	0.044018	1.897288	6.858436	1.454217	1.853389	2.474278	7.471681	8.463677	7.138862	16.19	10.46511	24.6572	18.20688	16.91074	77.62846	47.38817	45.31815
2018-10-01	0.265246	-0.00905	15.41482	11.32512	7.035293	9.002825	2.917493	5.973727	5.489145	8.346964	1.302094	8.933473	24.14684	29.84577	15.69267	69.79386	68.18168	12.81185
2019-04-01	-1.39772	-8.37385	-61.3175	-34.7717	-11.4302	-13.8012	-11.8419	18.37412	2.649689	76.20862	13.51452	10.44969	2.845689	14.46409	16.50712	70.8933	62.6164	45.9212
2019-10-01	-0.50726	-0.94302	12.50307	2.422102	-1.8216	-3.23351	-6.28466	9.400482	4.36193	12.83065	16.20557	13.96955	27.31503	18.9453	14.4258	64.52779	61.21443	3.090662
2020-04-01	-0.87077	2.311808	19.53912	-22.0591	14.91724	10.16322	8.491226	-4.66878	-3.6086	-5.09052	39.87473	-132.596	-113.417	-48.7061	206.1549	229.459	162.7146	-223.641
2020-10-01	-0.42781	-1.5858	-5.11221	-19.1196	2.635489	-0.17471	0.544496	12.09102	9.841662	10.25784	18.23532	1.989016	-1.51809	66.50004	8.585029	95.85521	-26.1789	120.5109
2021-04-01	-0.91577	-0.29611	13.80745	-5.0452	-8.70197	-15.3173	-5.13675	25.13401	23.85455	29.7768	-25.9812	-6.44749	-18.9768	-74.782	49.79323	205.5074	222.5004	-196.324

Appendix

USD account transaction fee

	SPY	QQQ	VWO	EWC	EFA	VGK	IOO	SHY	IEF	TIP	IYR	Tot
2016-10-01	1.9995	3.8156	1.5110	3.2696	0.8461	1.9571	2.7552	4.7429	1.8139	5.6617	16.0503	44.4229
2017-04-01	2.0755	1.2226	10.3500	1.6613	5.5301	7.7781	2.1277	1.9351	6.2564	16.7514	0.2863	55.9745
2017-10-01	0.2944	0.0628	0.0682	0.1659	0.1248	0.0864	0.0554	4.4140	4.2443	5.8033	4.4368	19.7562
2018-04-01	0.3253	0.0346	0.3972	0.8946	0.4653	0.4921	0.5311	2.9676	4.0717	3.7310	5.5602	19.4707
2018-10-01	0.3415	0.0075	2.7229	1.4030	2.0270	2.1332	0.6332	2.3879	2.6436	4.3079	0.4709	19.0787
2019-04-01	1.9754	7.8218	12.5290	4.7168	3.5579	3.5617	2.7923	7.5119	1.3592	41.1501	5.5145	92.4906
2019-10-01	0.7466	0.9198	2.5112	0.3342	0.5850	0.8540	1.5467	3.9251	2.4039	7.1959	7.2709	28.2934
2020-04-01	1.2407	2.5153	3.4411	2.6025	4.0647	2.2487	2.0528	2.0109	2.1688	2.9983	14.7175	40.0614
2020-10-01	0.6910	2.1269	1.1059	2.4842	0.7904	0.0421	0.1462	5.2099	5.8700	6.2618	6.9472	31.6755
2021-04-01	1.9045	0.4998	3.6385	0.8928	3.3527	5.0002	1.7624	10.8358	13.5602	18.5634	12.8209	72.8312
Tot	11.5945	19.0266	38.2749	18.4249	21.3439	24.1537	14.4030	45.9411	44.3920	112.4249	74.0753	424.0549

Appendix

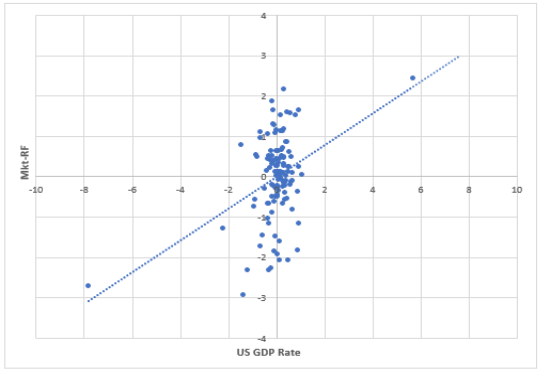
CAD account transaction fee

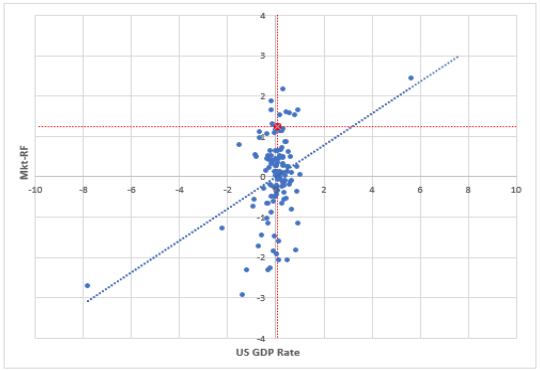
	XSP.TO	XIU.TO	XIN.TO	XBB.TO	XGB.TO	XRB.TO	XRE.TO	Tot
2016-10-01	14.7158	8.8458	14.9644	25.4351	10.9298	5.4254	28.2644	108.5806
2017-04-01	0.1500	1.0264	0.1144	2.5796	8.5165	10.4663	2.6756	25.5288
2017-10-01	0.1018	1.0543	0.1867	2.2780	7.2508	7.8849	6.2435	25.0000
2018-04-01	1.4891	2.5983	2.2205	2.3537	7.6120	5.4785	3.2478	25.0000
2018-10-01	1.3052	2.5046	3.4602	2.1768	6.8129	7.7647	0.9756	25.0000
2019-04-01	1.6558	0.3335	1.8113	2.4345	7.3567	7.5632	3.8452	25.0000
2019-10-01	2.2886	3.2245	2.4422	2.2077	6.9382	7.6145	0.2842	25.0000
2020-04-01	20.6290	12.3213	5.3591	32.9435	26.0120	20.2769	15.9230	133.4649
2020-10-01	0.3489	0.1748	7.6786	1.3951	10.9447	3.5096	8.3170	32.3688
2021-04-01	1.4445	2.7192	10.8560	7.7992	22.3406	27.6100	17.7300	90.4996
Tot	44.1288	34.8028	49.0935	81.6032	114.7141	103.5940	87.5064	515.4427

Appendix

US GDP vs Mkt-RF

Relationship

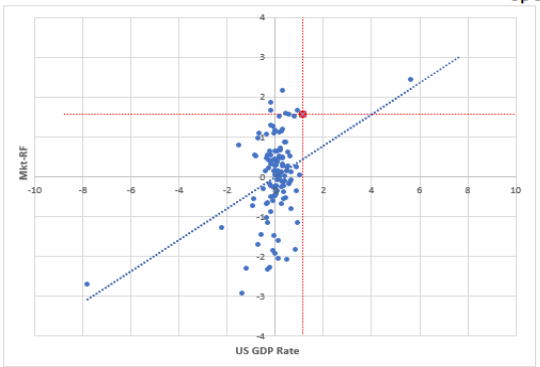




Base Scenario

US GDP	Mkt-RF
0.06568	1.23504

Up Senario



Down Scenario