Multi-Factor Investment and Risk Assessment

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Presentation to the Board of Risky Partner Investments

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HWY Capital

Agenda

1 | Canadian Equity Market and Multi-Factor Identification

2 | Data Processing and Stepwise Regression

3 | Model Accuracy and Cross Validation

4 | Market Risks and Beta Exposures

5 | Credit Risks and Beta Exposures

6 | Liquidity Risks and Beta Exposures

7 | Optimal Risk-Return ETF Portfolio Construction

Factor Selections

Risky Partners

Overview of Risky Partners

- British investing firm with an interest in investing in Canadian smart beta companies
- Requested an in-depth risk analysis on smart beta investment strategies

Objectives

- Develop a predictive stock return model using multi-factor betas
- Analyze market, credit, and liquidity risks for each company with varying exposures to each factor
- Create an optimal risk-return smart beta ETF portfolio and advice on composite companies

Canadian Equity Market – Neutral

- S&P/TSX forward P/E of 13.2x vs. 10-yr average of 14.6x
- Higher interest rates on leveraged consumer and housing markets – **Consumer Defensive**
- Lack oil pipeline capacity; increasingly self-sufficient US oil market; rising oil prices – **Energy**
- Improved valuations of banks but in-line with Canadian market and US banks – **Financial Services**
- Waning economic competitiveness; traditional reliance on cyclical and capital intensive sectors (**Utilities**) vs. high growth businesses (**Healthcare** and **Technology)**

Factors

1. Systematic Risk (equity market risk premium)
2. Size Effect (SMB)
3. Value Effect (HML)
4. Profitability (RMW)
5. Investment (CMA)
6. **Exchange Rate changes (EX)**
7. **Oil Price changes (OIL)**

Explanation of Factors

- Developed a Fama French Five Factor model with two additional factors: exchange rates and oil prices
- Additional factors attempt to encapsulate the following effects:
    - Using US market returns to evaluate betas on Canadian companies (EX)
    - The large dependency of the overall Canadian economy on oil price changes (OIL)

Details on Fama French and data bank: French, Kenneth R. 2019. Kenneth R. French - Data Library. March 12. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

Stepwise Regression

Royal Bank of Canada (RY)

Starting factors, AIC = -259.43						
EX	OIL	SMB	HML	RMW	CMA	SP
-261.3	-260.9	-260.9	-260.1	-256.1	-253.7	-244.6

First step: removed EX
New AIC = -261.3

RMW	OIL	SMB	HML	CMA	SP
-262.9	-262.8	-262.13	-257.29	-266.44	-246.67

Second step: removed RMW
New AIC = -262.9

SMB	OIL	HML	CMA	SP
-264.1	-264.1	-256.9	-256.4	-248.66

Third step: removed SMB
New AIC = -264.1

OIL	HML	CMA	SP
-264.13	-258.65	-257.93	-250.21

Fourth step: removed OIL
Final AIC = **-264.13**

HML	CMA	SP
-260.13	-259.48	-246.81

Why Stepwise Regression?

- With seven factors there is a high possibility of **overfitting**
- Stepwise regression **removes unnecessary and uncorrelated factors** to prevent overfitting
- Model betas can vary from stock to stock depending on which market variables are correlated with the stock.

Procedure

Goal is to minimize **Akaike's Information Criterion (AIC)**

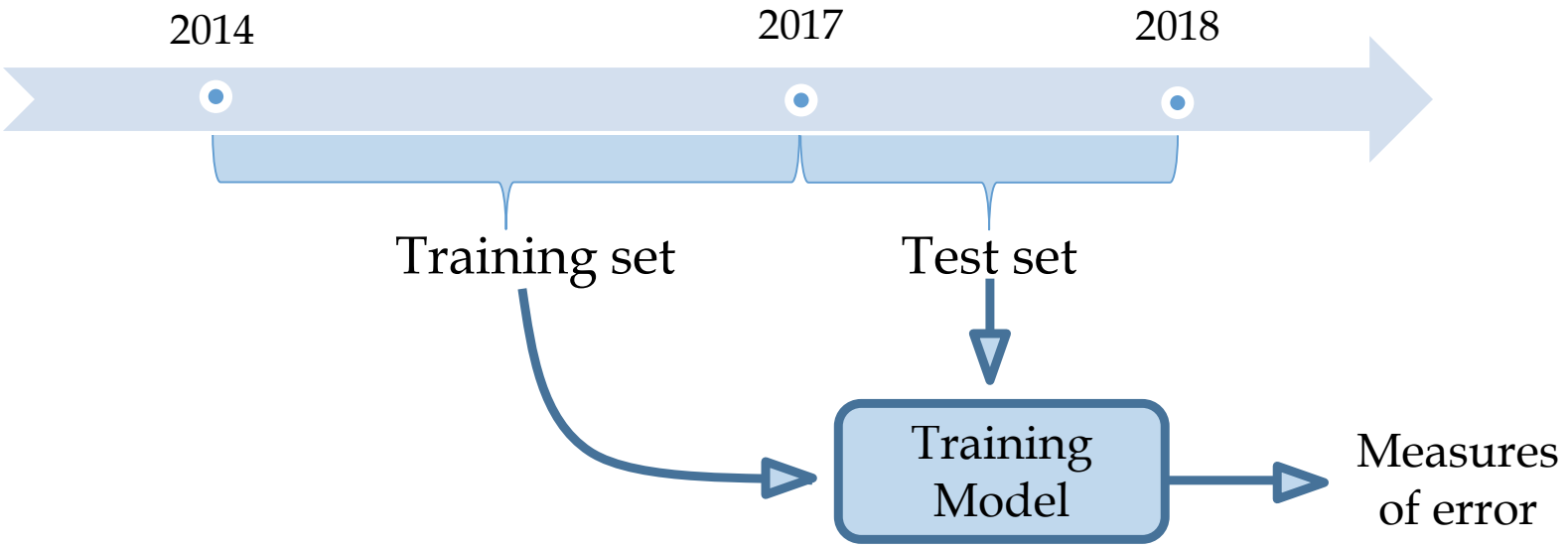
1. At each iteration, AIC is calculated when each variable is removed
2. The model updates and removes the variable for which the lowest AIC was calculated
3. The process repeats until AIC is not lowered by removing a variable

For this example, removing one more factor increases AIC after the fourth iteration; thus, we end the algorithm and include all remaining factors in our model.

Details on stepwise regression: Sheather, Simon J. 2009. A Modern Approach to Regression with R. New York: Springer.

Cross Validation

Procedure



Sample Results

Suncor Energy Inc.		
r^2	RMSE	MAE
0.743	0.035	0.026

TerraVest Industries Inc.		
r^2	RMSE	MAE
0.000	0.052	0.042

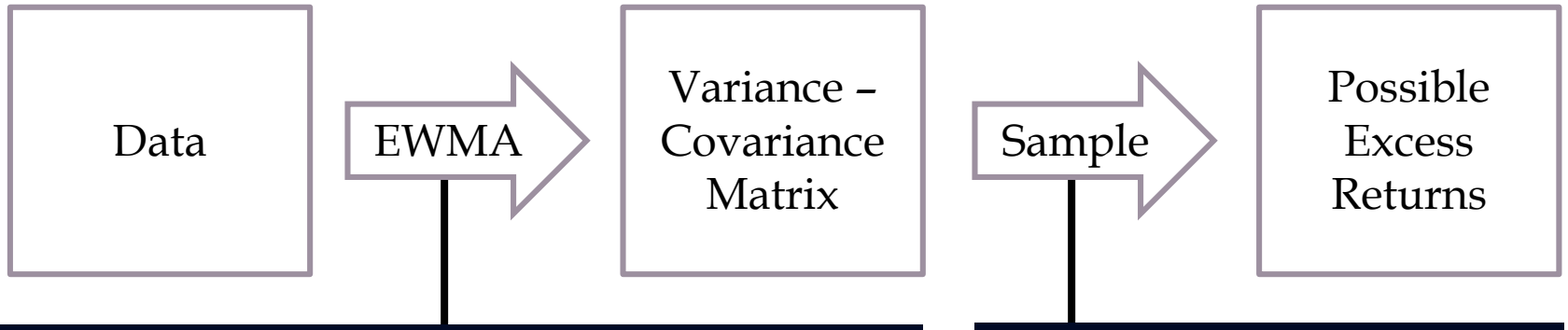
[1]*Full results are in the appendix*

Discussion

- Cross validation is used to test **model accuracy**
- Our model specifically trains on data before 2017 and is tested on data in 2018
- Observed **measures of error** are the coefficient of determination (r^2), Root Mean Square Error (RMSE), and Mean Absolute Error (MAE)[1]
- Larger businesses tend to have higher measures of model accuracy compared to smaller businesses

Procedure for evaluating Market Risk

The end goal of our testing is to calculate a **99% Value at Risk (VaR)** and **Expected Shortfall (ES)**.



Exponentially Weighted Moving Average (EWMA) Model

- Estimating accurate volatilities for stock movements and correlations between each stock and market variables are essential to run accurate simulations.
- To attain good estimates, we used an **Exponentially Weighted Moving Average** (EWMA) model to estimate **current volatility** of stock price movements and its **correlation** with market variables.
  - The EWMA model **weights recent data** more heavily in the estimation of the volatility of returns because recent events have a bigger impact on future volatility (Hull 2015)[1].
  - We used standard industry practice and assumed $\boldsymbol{\lambda = 0.94}$.

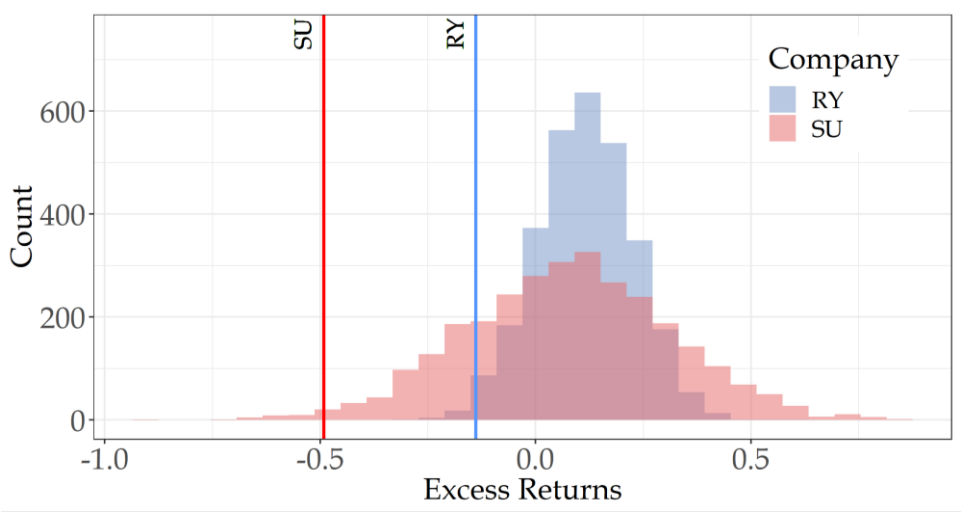
Sampling Procedure

- We assumed normality of our monthly market variable changes[2].
- The assumption allows us to randomly sample from a multivariate normal distribution with:
  - $\boldsymbol{\mu}$ as the expected returns or changes on the stock and market variables; and
  - $\boldsymbol{\Sigma}$ as the EWMA variance-covariance matrix output.

[1]*For details on the EWMA model refer to: Hull, John C. 2015. Risk Management and Financial Institutions. Hoboken, NJ: John Wiley & Sons.*
[2]*check appendix for Q-Q plots.*

Market Risk | Value at Risk and Expected Shortfall

99% Value at Risk



- The figure above is a visualization of the sample of excess stock returns from slide six. We compared the distribution of RY and SU to show the difference between low and high volatility stocks.
- The coloured lines indicate the Value at Risk calculated from our sample.

Sampling Outputs

- The table gives a quick way of identifying how much we can **expect to lose** on any stock in the **event of poor market performance**.
- **Expected Shortfall** is used to evaluate market risk because it satisfies the properties of a coherent measure[1].
- VaR represents a **boundary point** whereas ES represents how much we **expect to lose** in the event of poor market performance.

	VaR	ES
AGT	-93.51%	-103.29%
AD	-67.47%	-76.98%
WEED	-100.90%	-142.57%
CSH-UN	-23.92%	-28.70%
CSU	-29.34%	-33.25%
DOL	-60.96%	-66.85%
H	-30.27%	-34.78%
KXS	-67.07%	-83.53%
MFI	-36.94%	-44.61%
NPI	-31.91%	-37.64%
PKI	-41.23%	-50.08%
RY	-14.11%	-17.07%
SU	-45.49%	-56.77%
SPB	-46.37%	-51.87%
TCS	-57.69%	-70.38%
TVK	-21.28%	-26.56%
X	-14.23%	-21.83%
ZYME	-202.40%	-232.69%

[1]*A coherent measure satisfies four properties: 1) monotonicity, 2) translation invariance, 3) homogeneity, and 4) subadditivity. The definitions of which can be found in (Hull 2015).*

Credit Risk

Selected Implied Credit Ratings from Interest Coverage Ratios[1]

	16Q1	16Q2	16Q3	16Q4	17Q1	17Q2	17Q3	17Q4	18Q1	18Q2	18Q3	18Q4	Current
AGT	BB	BB	BB	BB+	CCC	CCC	D	D					B stable
CSH-UN	CC	CC	CCC	B-	CC	CCC	B-	CC	CC	CCC	CCC	CC	BBB-stable
NPI	B	CCC	B-	A-	A-	B+	CCC	BBB					BBB
SPB	A-	D	D	A+	A+	CC	D	A-					BB
X	BB+	BBB	BB+		BBB	A-	BB						A+

Identified Discrepancies

The end goal is to identify mispriced companies which do not reflect current credit risks.

AGT (*AGT*)
- Depressed lentil market (pulse is 51% of revenue in 2017), decreasing profitability
- Highly leveraged, large debt refinancing in 2020 ⇒ in talks of privatization

Chartwell (*CSH-UN*) and TMX (*X*)
- Stable credit rating implied by interest coverage ratios, but below market rating
- Strong long term organic growth and stable operations

Northland Power (*NPI*) and Superior Plus Corp (*SPB*)
- Credit rating implied by interest coverage ratios fluctuates across quarters
- Intrinsic volatility in energy prices and energy industry factors

Implied Ratings[2]

Market Cap > $5 billion

>	≤ to	Rating
	0.2	D
0.2	0.65	C
0.65	0.8	CC
0.8	1.25	CCC
1.25	1.5	B-
1.5	1.75	B
1.75	2	B+
2	2.25	BB
2.25	2.5	BB+
2.5	3	BBB
3	4.25	A-
4.25	5.5	A
5.5	6.5	A+
6.5	8.5	AA
8.5		AAA

Market Cap < $5 billion

>	≤ to	Rating
	0.5	D
0.5	0.8	C
0.8	1.25	CC
1.25	1.5	CCC
1.5	2	B-
2	2.5	B
2.5	3	B+
3	3.5	BB
3.5	4	BB+
4	4.5	BBB
4.5	6	A-
6	7.5	A
7.5	9.5	A+
9.5	12.5	AA
12.5		AAA

[1] *EBIT/Interest coverage ratio; data on selected companies, remaining companies can be found in Appendix*

[2] *Ratings, Interest Coverage Ratios and Default Spread (Aswarth Damodaran)*

Liquidity Risk

Excessive Liquidity Risks

Zymeworks (*ZYME*)

April 2017 IPO, $649 M equity, $13.56 - $30.36 (52-week)

TerraVest Industries (*TVK*)

$213.3 M equity, $9 - $13.41 (52-week)

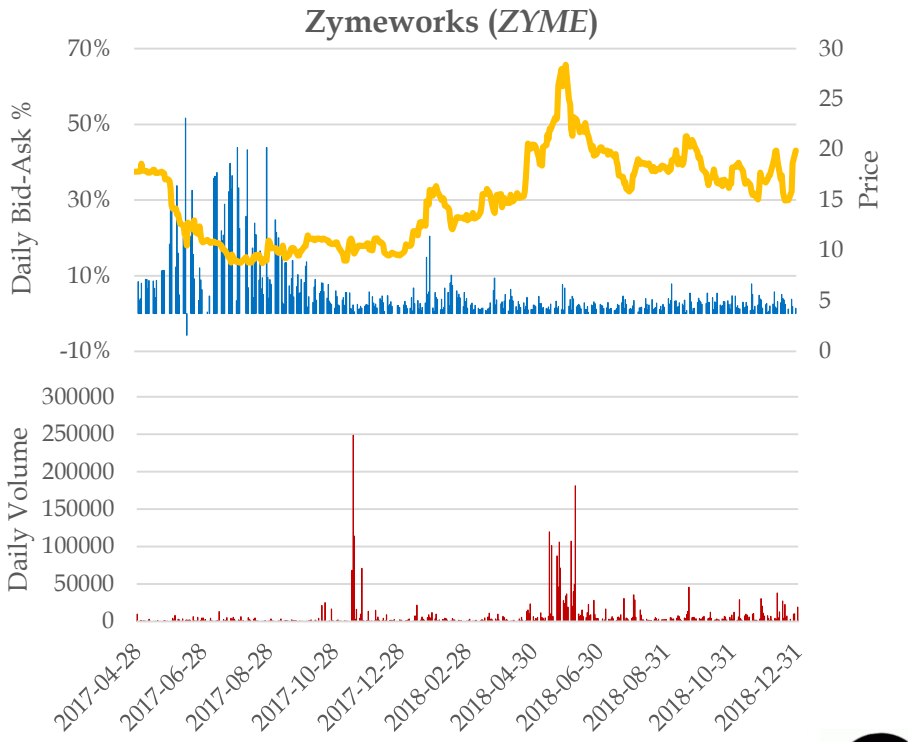
TECSYS (*TCS*)

$175.9 M equity, $10.3 - $17.5 (52-week)

Market and ETF Portfolio Liquidity

- Illiquid securities have a discrepancy between **NAV** and value of **underlying equities**
- Avoid holding large positions in illiquid companies
- Liquidity of ETF portfolio primarily determined by underlying liquidity of composite equities and these factors:
  - Market Cap of Security > $1 bn
  - Low Risk Profile
  - Domicile equities traded in TSX
- Further stress tests required for liquidity conditions using stress event scenarios (2008 GFC)

	Volume	Bid-Ask		Volume	Bid-Ask
AGT	77,477.13	0.80%	**NPI**	293,503.80	0.56%
AD	136,180.18	0.69%	**PKI**	276,321.92	0.53%
WEED	2,274,844.74	0.29%	**RY**	2,424,885.88	0.11%
CSH-UN	296,254.35	0.53%	**SU**	3,131,293.10	0.16%
CSU	43,672.39	0.70%	**SPB**	351,866.85	0.55%
DOL	1,099,532.40	0.22%	**TCS**	8,024.88	1.71%
H	443,685.41	1.16%	**TVK**	8,626.30	2.82%
KXS	71,795.37	0.71%	**X**	66,366.61	0.75%
MFI	272,961.43	0.44%	**ZYME**	7,821.33	5.00%



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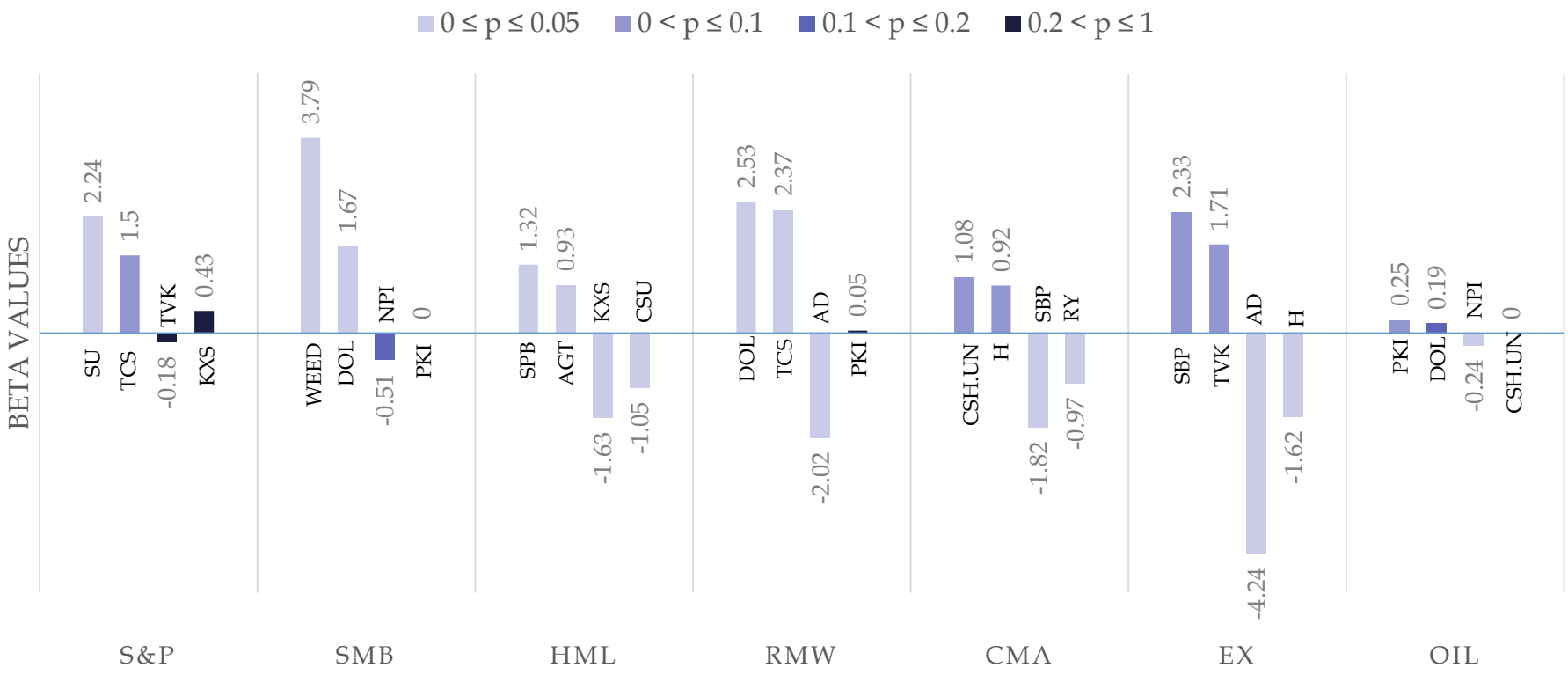
Summary of Betas



Beta Discussion

- Stocks with extreme ES tend to have extreme betas because a small change in the beta variable will have a multiplied effect on the stock value.
- E.g. Canopy has a beta value of 3.79 with SMB; if SMB goes down, we can expect Canopy to go down 3.79 times as much as SMB. Canopy's ES (-142.57%) reflects the nature of high beta stocks.

If beta did not show up in stepwise regression, we used the beta from the full model form.

Summary of Results

Companies with high exposure to:

- SMB or OIL exhibit higher market risks;
- HML or EX have higher credit risk;
- RMW have higher market and liquidity risks;

Companies with low exposure to:

- HML have lower market risks
- OIL are associated with credit risk.

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Violations of Risk and Selection Criteria for ETF Portfolio

Criteria

To be considered for the ETF portfolio, we wanted to pick companies with:

1. Good financial **fundamentals**
2. Within **market risk** preferences;
3. Within desired **credit risk tolerance**; and
4. Within **liquidity risk tolerance**.

We limit the weighting of the stock in our portfolio selection if the stock does not meet the criteria.

One violation ⇒ maximum **15%** of portfolio weight

Each additional violations ⇒ **-5%** of portfolio weight

Definition of Violations

A violation in:

1. The fundamental section if the company has
    a) Negative revenue growth
    b) Low profitability compared to industry
    c) Highly levered
    d) Overvalued implied by trading multiples[1];
2. Market risk is any ES below $\ln(0.5) \approx -70\%$;
3. Credit risk are companies with a higher calculated credit risk than its credit rating
4. Liquidity risk are stocks that have a bid-ask spread above 1% of stock price

	Fundamental	Market Risk	Credit Risk	Liquidity Risk
AGT		-103.29%	x	0.80%
AD		-76.98%		0.69%
WEED	x	-142.57%		0.29%
CSH-UN	x	-28.70%	x	0.53%
CSU		-33.25%		0.70%
DOL	x	-66.85%		0.22%
H		-34.78%		1.16%
KXS	x	-83.53%		0.71%
MFI		-44.61%		0.44%
NPI		-37.64%	x	0.56%
PKI		-50.08%		0.53%
RY		-17.07%		0.11%
SU		-56.77%		0.16%
SPB	x	-51.87%	x	0.55%
TCS	x	-70.38%		1.71%
TVK		-26.56%		2.82%
X		-21.83%	x	0.75%
ZYME	x	-232.69%		5.00%

[1] *fundamentals data for the companies are in the appendix*

Portfolio Risk and Exposures

Optimal Tangency Portfolio

Sharpe Ratio

- Risk-adjusted return, excess return per unit of volatility of returns (proxy for portfolio risk)
- Assumes returns are normally distributed

Traditional CAPM for expected returns

- Risk-free rate of 2.35% (10-year Treasury)
- Reasonable assumption for equity market risk premium of 5%

Computed variance-covariance

- Used the EWMA model to get current variance-covariance for the stocks in consideration

Portfolio Statistics	
Expected Return	8.14%
Volatility	17.2%
Sharpe Ratio	0.3367

Portfolio Betas			
SP	1.07	**CMA**	-0.26
SMB	0.09	**EX**	0.44
HML	0.12	**OIL**	0.01
RMW	0.23		

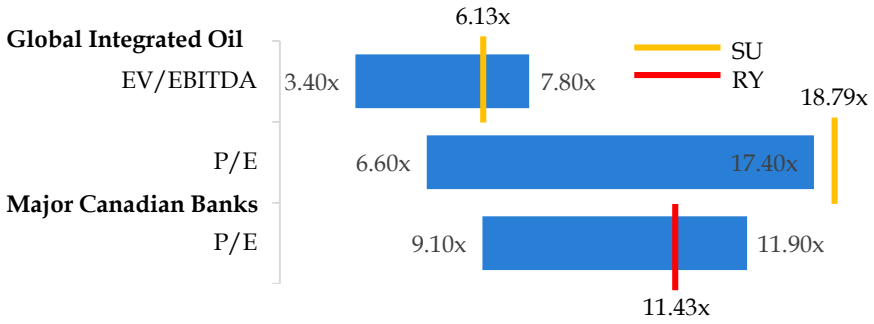
Industry Exposure and Analysis

Global Integrated Oil (Suncor Energy, 24%)

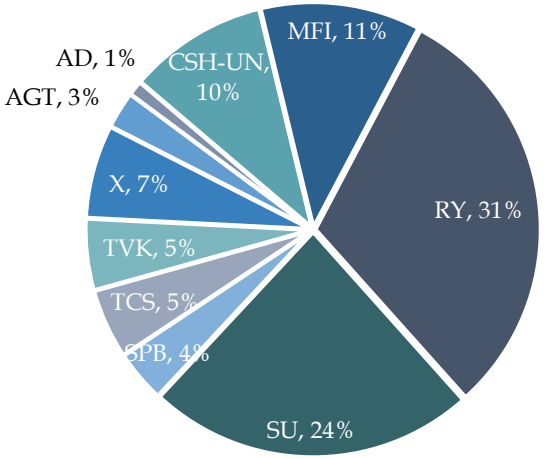
- Transition to energy from non-fossil fuel sources
- Robust resource base and integrated business model

Major Canadian Banks (Royal Bank of Canada, 31%)

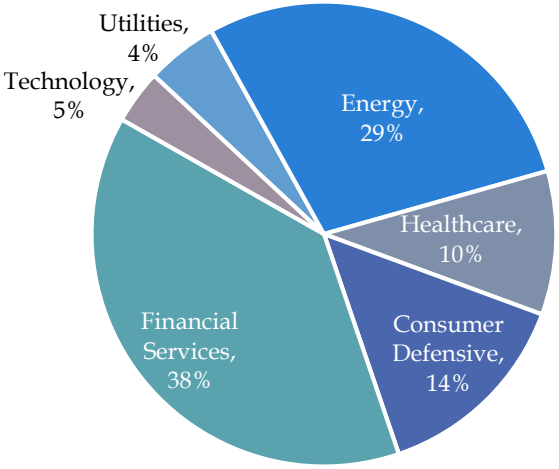
- Well capitalized (11.38% CET1) and 3.4% of GDP
- Expansion into US and use of technology



Portfolio Composition



Industry Exposure



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Appendix

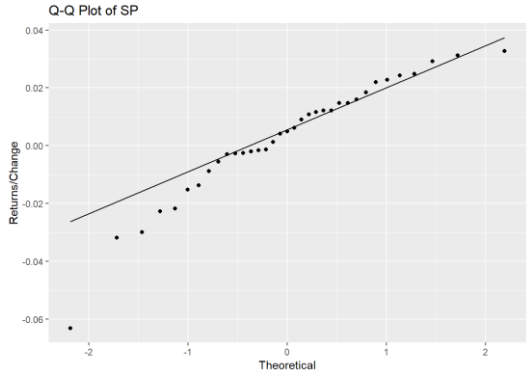
Model Outputs From Stepwise Regression

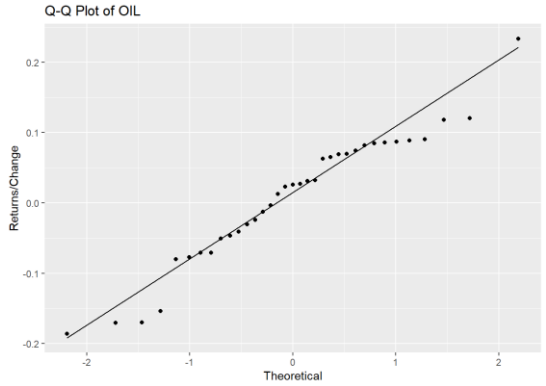
	S&P500		SMB		HML		RMW		CMA		OIL		EX	
	β	P	β	P	β	P	β	P	β	P	β	P	β	P
AGT					0.93	0.04								
AD							-2.02	0.02					-4.24	0.01
WEED			3.76	0.05										
CSH.UN	0.73	0.03			-0.92	0.03			1.08	0.08				
CSU					-1.05	0								
DOL			1.67	0.01			2.53	0			0.19	0.12		
H					-0.79	0.03			0.92	0.09			-1.62	0.03
KXS					-1.63	0.01								
MFI	1.02	0.02			-0.46	0.19	1.16	0.08						
NPI	1.58	0	-0.51	0.18							-0.24	0.01		
PKI					-0.77	0.08					0.25	0.06		
RY	0.91	0			0.62	0.01			-0.97	0.01				
SU	2.24	0											1.32	0.17
SPB					1.32	0.04			-1.82	0.05	0.25	0.02	2.33	0.06
TCS	1.5	0.09					2.37	0.05						
TVK			0.7	0.07									1.71	0.09
X			0.85	0.05										
ZYME					-4.9	0.04	-7.35	0.06					7.27	0.18

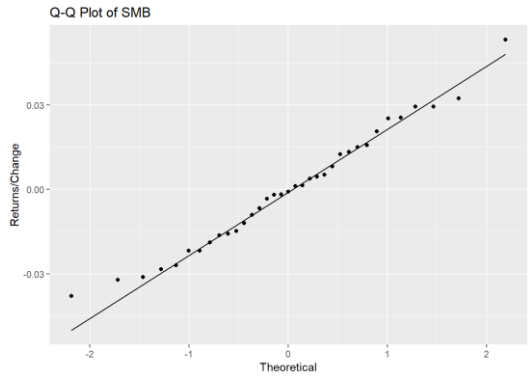
Cross Validation Measures of Errors

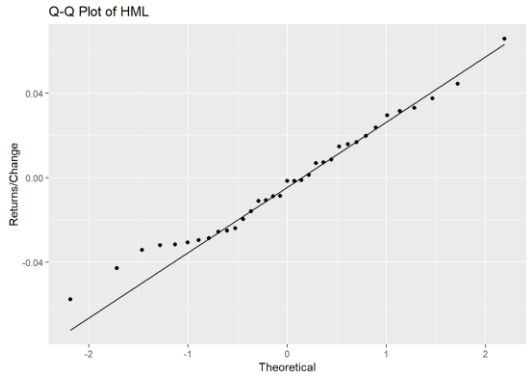
	r^2	RMSE	MAE		r^2	RMSE	MAE
AGT	0.02	0.08	0.06	**NPI**	0.23	0.05	0.04
AD	0.01	0.09	0.07	**PKI**	0.35	0.06	0.05
WEED	0.64	0.32	0.27	**RY**	0.25	0.03	0.02
CSH.UN	0.03	0.05	0.04	**SU**	0.74	0.03	0.03
CSU	0.04	0.06	0.05	**SPB**	0.00	0.06	0.05
DOL	0.05	0.09	0.08	**TCS**	0.12	0.08	0.08
H	0.06	0.04	0.04	**TVK**	0.00	0.05	0.04
KXS	0.33	0.08	0.06	**X**	0.15	0.05	0.04
MFI	0.08	0.06	0.05	**ZYME**	0.22	1.70	1.39

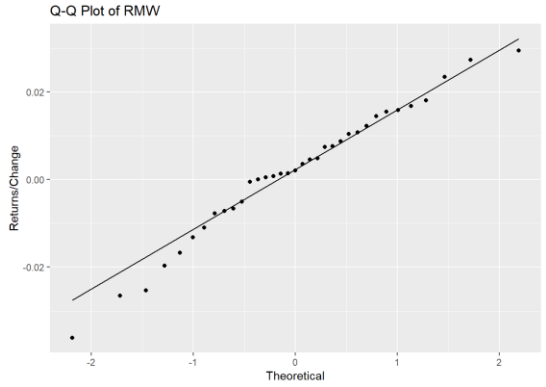
Q-Q Plots

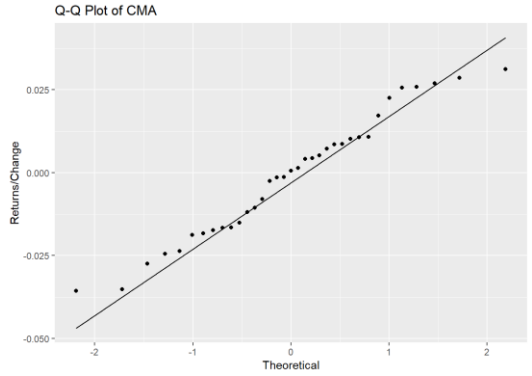


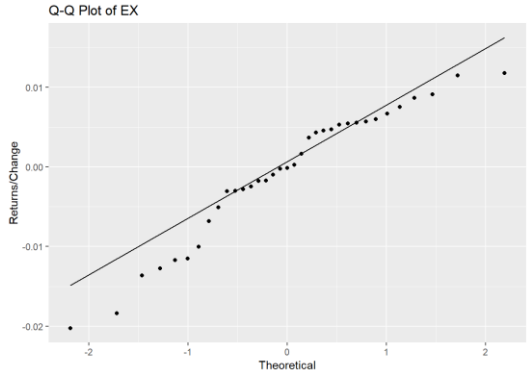












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Implied Credit Ratings

	16Q1	16Q2	16Q3	16Q4	17Q1	17Q2	17Q3	17Q4	18Q1	18Q2	18Q3	18Q4	Current
AGT	BB	BB	BB	BB+	CCC	CCC	D	D					B stable
AD	AAA	AAA	AAA	AAA	A+	AAA	AAA	A-	D	AAA	AAA	D	A-
WEED			D				AAA						BB
CSH-UN	CC	CC	CCC	B-	CC	CCC	B-	CC	CC	CCC	CCC	CC	BBB- stable
CSU	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA					BBB
DOL	AAA	AAA	AAA	AAA	AAA								BBB stable
H	A-	BBB	A-	A-	BBB	BB+	A-	BBB					A-
KXS													BBB+
MFI	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA					A
NPI	B	CCC	B-	A-	A-	B+	CCC	BBB					BBB
PKI	A	A-	A-	A-	A-	B+	B-	A+					BB+
RY													AA- stable
SU	D	D	A+	AAA	AAA	AA	AAA	AAA	AAA	AAA	AAA	A-	A- stable
SPB	A-	D	D	A+	A+	CC	D	A-					BB
TCS													BBB-
TVK	B+	D	A	A	B	B+	BB+						BB-
X	BB+	BBB	BB+		BBB	A-	BB						A+
ZYME													BB+

Fundamentals

	Rev growth (5 yr CAGR)	EBITDA margin (5 yr)	Industry	EBIT margin (5 yr)	Industry	ROIC (5 yr)	Industry	ROE (5 yr)	Industry
SU	-0.67%	29.31%	16.35%	11.03%	7.54%	3.04%	5.91%	3.98%	7.85%
PKI	17.69%	4.08%	7.44%	2.45%	5.04%	4.32%	7.01%	8.03%	11.53%
TVK	19.66%	15.28%	12.55%	10.30%	8.39%	9.54%	4.57%	14.44%	7.17%
KXS	26.06%	20.49%	17.84%	17.09%	12.46%	12.68%	13.71%	16.11% (4 yr)	18.21%
TCS	11.16%	5.59%	30.41%	3.55%	17.46%	12.77%	9.05%	13.82%	14.89%
CSU	11.75%	32.24%	17.84%	28.34%	12.46%	12.52%	13.71%	27.23%	18.21%
WEED	226.55% (4 yr)	-218.66%	4.45%	-378.50%	2.24%	-10.31%	0.69%	-5.55%	1.96%
CSH-UN	0.04%		53.25%	-0.29%	50.46%	0.27%	3.37%	0.71%	6.45%
NPI	19.61%	61.78%	60.50%	38.49%	35.00%	0.83%	1.53%	8.99%	5.56%
H	-1.28%	32.13%	33.71%	19.81%	18.86%	3.98%	2.26%	7.92%	5.55%
SPB	-8.94%	11.41%	7.44%	6.62%	5.04%	2.02%	7.01%	4.32%	11.53%
AGT	8.5501% (4 yr)	5.22% (4 yr)	4.45%	4.11%	2.24%	0.43%	0.69%	0.68%	1.96%
DOL	12.15%	21.13%	7.19%	19.90%	5.13%	31.06%	11.39%	85.923% (4 yr)	18.16%
AD	15.38%			71.02%		7.20%	1.78%	8.30%	5.86%
RY							8.88%	16.49%	13.94%
MFI	19.66%	15.28%	9.42%	10.30%	7.27%	9.54%	10.43%	14.44%	14.24%
X	6.35%			33.21%		3.83%	4.43%	4.70%	5.39%
ZYME	147.08%	-266.52%	34.48%	-276.77%	26.02%	-36.18% (3 yr)	14.36%	-37.52% (3 yr)	22.48%

	Market cap (CAD M)	Debt/Capital (5 yr)	Industry	PE	Industry	PB	Industry	EV/EBITDA	Industry
SU	68,947	27.09%	30.18%	18.79x	18.18x	1.37x	1.12x	6.13x	6.70x
PKI	5,603	48.80%	42.69%	22.71x	22.47x	2.62x	2.36x	6.29x	9.98x
TVK	213.3	46.19%	36.65%	11.28x	27.74x	2.22x	1.82x	7.35x	10.91x
KXS	1,972	92.00%	26.92%	95.15x	27.12x	6.85x	4.93x	40.16x	14.78x
TCS	175.9	9.24%	39.15%	51.33x	73.44x	4.67x	3.46x	35.24x	14.18x
CSU	31,563	56.57%	26.92%	18.66x	27.12x	5.06x	4.93x	17.93x	14.78x
WEED	20,857	2.49%	43.17%			3.31x	3.52x		10.81x
CSH-UN	3,187	70.88%	50.40%	156.95x	16.30x	3.07x	1.00x	18.49x	18.46x
NPI	4,574	85.14%	71.85%	14.47x	53.07x	4.82x	2.03x	10.10x	15.61x
H	12,145	52.83%	61.65%	15.51x	27.58x	1.20x	1.49x	11.07x	12.86x
SPB	1,971	55.14%	42.69%	15.48 (2016)	22.47x	1.55x	2.36x	9.22x	9.98x
AGT	431.2	58.28%	43.17%	41.64 (2017)		1.90x	3.52x	22.96x	10.81x
DOL	11,436	70.39%	41.47%	36.72x	20.12x		3.64x	24.07x	10.52x
AD	731			10.20x	37.64x	0.98x	1.61x	14.13x	
RY	148			11.43x	11.65x	1.88x	1.62x		
MFI	255	46.19%	29.38%	11.28x	21.92x	2.22x	3.07x	7.35x	13.99x
X	4,724	27.35%		13.76x	21.76x	1.08x	1.13x	10.88x	
ZYME	649	1.5575% (4 yr)	39.81%		21.04x	2.60x	4.74x		13.40x