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Back-Testing a Multi-Layer Investment Philosophy

Michaela Anderson
University of Portland

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UNIVERSITY OF PORTLAND

Back-Testing a Multi-Layer Investment Policy

Senior Honors Project

Michaela Anderson

Spring 2015

Introduction

The idea for this project came from a desire to do something practical, real-world, and directly applicable to what I hope to do upon graduation, which is financial planning. The initial thought was to find a financial advisor who had a problem they needed help with that could be turned into some type of research paper. The idea appealed to me for all the aforementioned reasons, but also because I would get the chance to add value and provide a service to a financial advisor in the Portland area. Fortunately, an advisor working for small, boutique advisory firm had just such a project for me – something that would benefit both him and his firm and provide hands on experience for me with something I could encounter as an advisor in the future. For reasons of confidentiality, neither the advisor’s name nor the advisor’s company name will be reported here. For the sake of simplicity, the advisor will be referred to as Robbie.

Robbie had an Excel document in which he had been back-testing his investment philosophy since October 31, 2007 on a hypothetical \$200,000 portfolio. From this, the goal of the project essentially became three-fold. The first goal was for me to check through the spreadsheets thoroughly, locating errors at the cell level. Essentially, this was done to ensure the spreadsheet actually operated correctly on the most fundamental of levels. The second goal was to bring the spreadsheet current through December 31, 2014. With everything else an advisor needs to do, this was not a top priority for Robbie. However, it was a good process for me to go through and consider how I might be able to analyze and test my own investment philosophy one day. Finally, the third goal was for me to consider some higher level questions. These questions were based on the assumptions that were built into the spreadsheet and, if incorrect, could lead to flaws in accurately back-testing the model. The rest of the report is laid in the following format:

background on the investment policy to give context, sections related to each of the three goals, and the results of the project.

Background – Investment Policy

Robbie has a very unique investment philosophy that he follows with his clients. The basics are this: the client’s portfolio is divided into 12 asset classes including 8 equity classes and 4 fixed income classes. Within those sub-classes, there may be multiple positions depending on the size of the portfolio. Each portfolio then follows one of five different models: aggressive, moderate aggressive, moderate, moderate conservative, and conservative. The breakdown of each of these is shown in the table below.

<i>Asset Class</i>	Aggressive	Moderate Aggressive	Moderate	Moderate Conservative	Conservative
<u>Equity</u>					
Large-Cap	11.25%	10.00%	7.50%	5.00%	2.50%
Mid-Cap	11.25%	10.00%	7.50%	5.00%	2.50%
Small-Cap	11.25%	10.00%	7.50%	5.00%	2.50%
Developed Nations	11.25%	10.00%	7.50%	5.00%	2.50%
Emerging Markets	11.25%	10.00%	7.50%	5.00%	2.50%
Commodities	11.25%	10.00%	7.50%	5.00%	2.50%
Natural Resources	11.25%	10.00%	7.50%	5.00%	2.50%
Real Estate	11.25%	10.00%	7.50%	5.00%	2.50%
Total	90.00%	80.00%	60.00%	40.00%	20.00%
<u>Fixed Income</u>					
Aggregate Bonds	2.50%	5.00%	10.00%	15.00%	20.00%
International Bonds	2.50%	5.00%	10.00%	15.00%	20.00%
TIPS	2.50%	5.00%	10.00%	15.00%	20.00%
Cash	2.50%	5.00%	10.00%	15.00%	20.00%
Total	10.00%	20.00%	40.00%	60.00%	80.00%

Table 1: Portfolio Models

The selection of model is based upon a client’s risk tolerance and investment needs. In particular, clients complete an industry standard risk tolerance questionnaire that generates a score. That score is then used to assign clients to one of the five models. Portfolios are rebalanced

periodically to stay on target with their asset allocations, starting by keeping the asset classes balanced and then moving to keep the holdings within those classes balanced.

Where the philosophy is truly unique, however, is in the buy-sell discipline. Essentially, when a holding falls below a percentage factor of its 200 day moving average (DMA), the entire position is sold in all client portfolios. When a position moves back above and closes above a percentage factor of its 200 DMA, the position is reentered. The following graph helps visualize this. When the stock price (the white line) dips below the 200 DMA (the pink line), the position would be sold, provided the move was substantial enough. When the stock price moves above the 200 DMA, the position would be reentered, once again provided the move was substantial enough.



Image 1: Stock Price and 200 Day Moving Average (Bloomberg)

The amount purchased when reentering a position depends on the model the client's portfolio is using. This is taken as an opportunity to balance this particular position, as discussed further later. More volatile positions in the portfolios are given more leeway in their percentage

factor so as to avoid trading unnecessarily. This investment philosophy is what the Excel document attempts to back-test in order to analyze if it can, in fact, outperform the market.

Part I – Fixing the Spreadsheets

Though perhaps the least glamorous or rigorous of all the tasks, fixing any errors within the calculations in the spreadsheets was a necessary component to ensure the investment philosophy was back-testing accurately. The Excel document contained a performance-calculating spreadsheet for each of the five models previously discussed. Fortunately, each was set up exactly the same and all trades based on the buy-sell philosophy would be made at the same time no matter the model. As such, only one of the spreadsheets needed to be combed through thoroughly and then the completed, fixed, and updated; information could then simply be copy and pasted to each of the other spreadsheets. Excel then updated values as necessary to reflect the new model based on the formulas in the cells.

The aggressive model's spreadsheet was checked over thoroughly twice. It was initially looked at in an effort to get a handle on how the document functioned, but then several hours were spent going through it very carefully to identify any formula errors. In doing so, several errors were found. Some formulas looked too far back in the previous columns, thereby using the wrong values for calculations, some used the initial values of different asset class investments to make calculations as opposed to what was actually in the portfolio in that moment, and others simply neglected to add in relevant values. Each of these errors was identified and then verified with Robbie that they were in fact mistakes and finally fixed.

In doing this part of the process, some changes were made to the spreadsheet as well. Because not every asset class was bought and sold with the same frequency, at times the

calculations needed to look really far back in the spreadsheet for relevant values. This is often where the errors seemed to occur. For this reasons, the formatting of the spreadsheet was altered so that the values in the “#Shares” column and “Cum Gain/Loss” column carried through, regardless of whether they had actually been sold or purchased with other transactions. This meant that when those assets were actually sold or purchased, the values needed for calculations were only a handful of columns back as opposed to much further. Additionally, this kept the formulas in columns more consistent, making it easier to verify that things had been done correctly. These carried-forward values were formatted differently to make it clear that they were not actual transactions, but rather just information being carried forward in the spreadsheet.

Once the aggressive model’s spreadsheet was also updated to include the more recent buy and sell transactions as well as a summary calculations of performance (as discussed in the next section), the spreadsheet was thoroughly checked over again for any errors missed previously or made in updating items. By doing so, several errors were found. A couple were simply minor formula errors that did not have a major impact on the return on investment of the portfolio. However, a couple were more significant. In one case, the gain/loss was calculated incorrectly, affecting that holding’s ultimate cumulative gain/loss. Additionally, in the calculation of the total market value (discussed more in the next section), cash had not been added to the total; this significantly impacted the return calculated on the portfolio. Once confident that the spreadsheet was complete and accurate, it was copy and pasted into the spreadsheets for the other models and spot-checked for proper functioning, thus completing the clean-up of the spreadsheets.

Part II – Bringing the Spreadsheets to Current

Adding Transactions

In order for the following section to be easier to understand, the screenshot from the Excel document will be useful for reference. In it, each row represents a different holding, one for each of the positions discussed in the background on the investment policy.

In				200 DMA	+/-	Out				200 DMA	+/-	Gain/Loss	Cum
Date	#Shares	\$/Share	Value	Value	%	Date	#Shares	\$/Share	Value	Value	%	Gain/Loss	Gain/Loss
1/10/2012	396.96	63.83	25,337.92	61.95	103.0%		396.96	81.05	32,173.56				1,665.27
1/19/2012	340.98	74.31	25,337.92	71.84	103.4%		340.98	93.41	31,850.56				1,851.12
1/18/2012	356.82	71.01	25,337.92	68.81	103.2%		356.82	90.24	32,199.60				2,535.15
9/14/2012	477.98	53.01	25,337.92	48.62	109.0%		477.98	60.19	28,769.84				(2,670.21)
12/11/2012	604.87	41.89	25,337.92	39.31	106.6%		604.87	42.59	25,761.33				(1,198.27)
	462.37						462.37	72.75	33,637.19				5,963.32
9/14/2012	305.94	82.82	25,337.92	75.70	109.4%		305.94	86.93	26,595.33				1,572.89
8/22/2012	880.09	28.79	25,337.92	27.46	104.8%	4/15/2013	880.09	25.63	22,556.82	27.71	92.5%	(2,781.10)	1,027.01
	48.23					6/21/2013	48.23	105.04	5,066.46	108.33	97.0%	306.77	972.70
	47.45					5/14/2013	47.45	118.23	5,610.56	119.77	98.7%	850.86	1,679.11
7/30/2012	97.18	57.94	5,630.65	57.33	101.1%	3/8/2013	97.18	57.18	5,556.79	58.70	97.4%	(73.86)	611.83
			5,630.65						5,630.65				
									255,408.69				

Image 2: Excel Spreadsheet Screenshot

The first step in bringing the spreadsheet to current was to add in any “ins” and “outs” (buys and sells) that were not already included in the spreadsheet. The goal was to bring the spreadsheet up to December 31, 2014, and this resulted in the addition of four transactions, two buys and two sells. With the way the spreadsheet was set up, this necessitated the addition of a two new “out” blocks (pink) and one new “in” block (green) to track these changes. One of the buy transactions was able to be tacked onto a previous “in” section. For the two buy transactions, the first step was to find the closing value of that holding on the day it was purchased. These were found using the historical prices on Yahoo Finance. Once these prices were found, the

number of shares purchased could be determined. This was calculated by multiplying the target percentage for that position by the most recent valuation of the holding (valued at the last “out” block) and then divided by the price per share. Using Bloomberg, the 200 DMA moving average for the position on that date was also determined and then the proportion of the price to the 200 DMA (as a percentage) was calculated. This completed the addition of the buy transactions.

The sell transactions, as recorded in the “out” blocks, required a bit more effort. At each sell, the entire portfolio needed to be valued. This meant each position needed to be accounted for. The number of shares simply carried forward from the previous purchase of a position, the price of the shares on the sell date was found on Yahoo Finance, and the position’s value was determined by multiplying these two together. The position values were then summed to arrive at the portfolio valuation on that sell date. Once again the 200 DMA was found using Bloomberg and the proportion of share price to 200 DMA calculated for each position. Further, for sells, the gain or loss on the sale was calculated by subtracting the value of the position at the sale from the value of the position at the last purchase. The cumulative gain and loss was then found by adding this recent gain or loss to the running total gain or loss for that position. This was repeated for the second sell transaction, completing this piece of updating the Excel document.

Updating Summary Information

Once again, having a screenshot from the Excel document to reference will make the discussion in this section easier to follow. As previously noted, each row represents a position, one for each of the categories referenced in the investment policy information.

Additionally, a summary section was completed regarding the buy and sell transactions completed on each holding. For each transaction, the number of buys and sells was calculated as well as the average DMA percentage at which these transactions occurred. This calculation allows Robbie to have a better understanding of how many transactions are being made as well as to inform to his clients at what percentage factor, on average, the transactions occur.

Finally, with all the other calculations completed, the return on investment for the portfolio under a given model could be found. This was done using Excel's internal rate of return function with the beginning value of the portfolio (\$200,000) on October 31, 2007 and the ending total value (\$316,779.48 for the aggressive model) on December 31, 2014. Originally, the internal rate of return had been calculated using the end valuation without considering the cumulative gains or losses. However, it made more sense to calculate the internal rate of return while factoring in these realized gains and losses, so the calculation was updated to reflect this (using the end total value as opposed to the end market value). The internal rate of return was also calculated over this time span, for means of comparison, on the S&P500, DJIA, and NASDAQ. With this final piece complete, the entire Excel document was checked over one more time for errors, as discussed in a previous section. Once assured of being free of errors, the entire spreadsheet of calculations was copy and pasted into the other models' spreadsheets to bring them to current as well. All said and done, each model's return increased by at least one percent after the corrections and updates.

Part III – Higher Level Concerns

While the relatively clear-cut tasks of updating the spreadsheet so it was current and locating and correcting any errors within the cells was a major feature of the project and an

important task to accomplish, there were higher level concerns to be addressed throughout too. Robbie did not just want to know that the Excel spreadsheet was error-free and complete – he wanted to know if there were assumptions he was making that were inaccurate or pieces missing that would throw off the results from the back-testing model. Thus, throughout working with the spreadsheet itself, time was devoted to considering the bigger elements present – or not present – in the model. This led to three primary concerns: transaction costs, the effects of rebalancing, and the appropriateness of the stand-in holdings in the model.

Transaction Costs

An immediate concern that arose when working with the spreadsheets was how to account for transaction costs. They did not seem to be accounted for in any of the calculations done within the spreadsheets. Transaction costs can have a significant impact on the performance of a portfolio as they eat away into returns. While Robbie's investment philosophy does not involve an overwhelming number of transactions, it involved enough buys and sells that it seemed like something that should be a consideration in calculating returns. As such, I had a discussion with Robbie about whether he thought they needed to be accounted for and, if so, how to go about doing so. Ultimately, Robbie indicated that they were negligible.

In a real client's portfolio, Robbie employs three broad categories of holdings. For starters, the primary funds used are no fee funds. This may mean it has a higher management fee, but that is irrelevant when speaking purely of transaction costs. The second group of funds contains fee funds. These cost \$25 when trading regardless of the size of the purchase or sell; because of these steeper costs, these are only employed when there will be a \$4,000 or greater investment in that position. Lastly, the third type of position is exchange traded funds (ETF's). To trade these, it costs \$7.95 for buys and sells regardless of the transaction size. While this all

may make it appear that there could be significant transaction costs missing from the model, ultimately on a typical portfolio of \$250,000, the annual costs for trading in total are generally less than \$100. Such a low number is negligible and does not need to be accounted for in the Excel model.

Effects of Rebalancing

Another concern that arose while working with the spreadsheets was how to account for rebalancing. As discussed in the background section of this report, Robbie's investment philosophy results in two types of buys and sells – one for the purpose of rebalancing periodically and one when the holding moves with respect to the 200 DMA. Thus, there are two different rebalancing mechanisms at play here. Within the Excel document, one mechanism is accounted for while the other is not. When the purchases are made back into the holdings as it moves above the 200 DMA, the amount purchased is calculated as a balanced amount of the portfolio. For example, when moving back into the large-cap holding, the percentage that holding should have in the portfolio was used to figure out how many shares to purchase based on the portfolio's latest value. This occurs in practice with Robbie's clients. When he moves back into a position, he purchases the appropriate amount of that position to balance that specific holding to its target. In this way, the Excel document reflects what is actually done in practice.

However, what the Excel document does not account for is the other rebalancing that occurs on clients' real accounts. This periodic rebalancing does not occur on a universal scale. While the buy-sell decisions based on 200 DMA movements occurs across all accounts that hold the position in question, periodic rebalancing is much more subjective and is considered on an account by account basis. Whether or not a position should be rebalanced to its target depends on many factors including how long they have been in the position, whether there has been

appreciation in that position, and factors regarding how the market seems to be moving (e.g. if the market is expected to continue to move upward, it may make sense to stay more heavily weighted in a position for a little while and then rebalance when this trend levels). Further, there is no hard and fast rule that Robbie applies to determine when rebalancing must occur. The lack of such a defining line is due to the factors just mentioned that make the decision to rebalance a client's account far more subjective than objective. Once again, this periodic rebalancing is not accounted for in the Excel model.

In considering whether the effect of rebalancing periodically should and could be included in the model, it first seemed that more costs needed to be accounted for because of the increased number of transactions. Thus, perhaps simply adding in some costs to account for this would be a simple fix. However, it quickly became evident that this was not the solution, and in fact there was no real solution. As previously seen, the transaction costs are negligible, so even with a few added transactions, they are not pressing to be included in the spreadsheets. What the spreadsheets are actually lacking is the benefit seen from rebalancing. Rebalancing is, fundamentally, a matter of keeping risk levels at the appropriate point for a given situation, but it also helps with return. As David Swensen states, “disciplined rebalancers sell what's hot and buy what's not” (2009). In other words, rebalancing forces the sale of assets that have appreciated and are therefore priced higher in order to buy what has depreciated and is therefore priced lower. This falls perfectly into buying low and selling high, the simplest, best strategy to maximize returns. Because Robbie has no clear-cut rule for when to rebalance a client's portfolio – that is, the choice is more subjective than objective – it cannot be factored into the Excel model, which is objective. Thus, the benefits likely caused by periodic rebalancing are not reflected in the outputs of the Excel model.

In summary, while the Excel document accounts for some rebalancing moves, it does not tell the whole story. As stated previously, there are two different instances of transactions at play, and when they do not occur simultaneously, there are more transactions occurring than the Excel document displays. These moves could have consequences on the returns. One effect could be the added transaction costs, but these are so minimal that they do not need to be added. However, what it is really missing from the Excel document are the benefits rebalancing generally has on returns. In other words, the Excel model may be slightly undervaluing returns.

Choice of Holdings

One of the fundamental assumptions made in the Excel model being used is that the holdings selected accurately represent the types of holdings in a client's portfolio. Since some of these ETF's are not actually used in the firm's daily practice, they need to be good matches for what is used in order to accurately reflect the performance of client portfolios. The indexes chosen for real estate, resources, commodities, and TIPS were assumed to be in-line with what they were meant to reflect provided the index was described to be invested in those items. The real estate, materials/resources, and TIPS ETF's are invested purely to match the index in those sectors and are therefore clearly good choices to use for the model. The commodities choice was a bit more complex as the fund was invested to exceed its benchmark through the use of commodity-like derivative instruments with the backing of actively managed, low volatility fixed income instruments, however it was considered to be a close enough match for what it was intended to represent (*PIMCO*, 2015). Most of the other choices of holdings seemed to match as well, with one exception that will be discussed later, but analysis was still done to ensure this was the case. The following sub-sections include discussions of those holdings.

International Treasuries – BWX

BWX is 99.84% invested in government treasuries with the remaining funds held in cash (*SPDR Allocation*, 2015). The following tables indicate that while the fund is allocated across a diverse set of countries, with the dominant one being Japan, over the past couple of years it has, in fact, been highly correlated with the U.S. Prior to this period it was doing a better job of being correlated to other areas, dominantly Japan and Europe, but lately it has been far more oriented toward the U.S. Since this holding is meant to capture the non-U.S. bond positions, this trend is a bit alarming in terms of its relevance for the model.

Country	Allocation
Japan	22.85%
U.K.	7.93%
Italy	6.64%
France	6.48%
Germany	5.20%
Canada	4.71%
Spain	4.66%
Netherlands	4.66%
Belgium	4.61%
South Korea	4.57%

Table 2: BWX Allocations

Factors/Dates	5-Jan-15	3-Jan-14	8-Jan-13	9-Jan-12	10-Jan-11
USL3TR Index (US Gov 5-7 years)	0.938	0	0.01	0	0.386
USL4TR Index (US Gov 7-10 years)	0	0.75	0	0	0
EUL3TR Index (Euro Gov 5-7 years)	0	0	0.037	0	0
EUL4TR Index (Euro Gov 7-10 years)	0	0.019	0	0	0
EUL5TR Index (Euro Gov 10+ years)	0	0	0.313	0.217	0.395
JNG5TR Index (Japan Gov 10+ years)	0.032	0	0	0	0
JGENVMUL Index (Africa/Middle East Gov)	0.013	0	0.107	0.093	0
JGENASUL Index (EM Asia Bonds)	0	0.017	0	0	0
JGENEUL Index (EM Europe Bonds)	0	0	0.533	0.451	0
JGENLAUL Index (Latin America Gov)	0.016	0.214	0	0.239	0.219

Table 3: BWX Fund Style Analysis

Aggregate U.S. Bonds – AGG

AGG is an ETF that looks to track the returns of an index made from the total U.S. investment-grade bond market (*iShares Core Security Description*, 2015). The fund is invested 91% in the U.S. with the remainder invested in Canada (less than two percent) and various other countries (each less than 1%) (*iShares Core Allocation*, 2015). Just over 40% of the fund is allocated to sovereign debt, which is reflected in the table below as the fund has been most highly correlated with U.S. sovereign debt, particularly more recently. However, it is also significantly correlated with U.S. corporate debt and U.S. mortgage debt. The fund description, its allocation, and what it is most correlated with indicate that the fund is a good choice to stand in for the aggregate U.S. bond position of the portfolio.

Factors/Dates	2-Jan-15	3-Jan-14	7-Jan-13	9-Jan-12	3-Jan-11
SBEID Index (Eurodollar)	0	0.012	0	0.276	0
SBCRP Index (US Corporate)	0.149	0.205	0.207	0	0.152
USL1TR Index (US Gov 1-3 year)	0	0.182	0	0	0
USL2TR Index (US Gov 3-5 year)	0.401	0	0.283	0.025	0
USL3TR Index (US Gov 5-7 year)	0.004	0	0.142	0	0.134
USL4TR Index (US Gov 7-10 year)	0.016	0.166	0	0.121	0
USL5TR Index (US Gov 10+ year)	0.108	0.026	0.044	0.034	0.053
SBHYMI Index (US High Yield)	0.023	0.095	0	0.021	0.018
SBMT Index (US Mortgage)	0.113	0.306	0.234	0.343	0.349
SPMUHT Index (US Municipal)	0.004	0.008	0.05	0.052	0.076
JPMTCAN Index (Canada Gov)	0	0	0	0	0.011
USC0TR03 Index (US 3m LIBOR)	0.182	0	0.04	0.128	0.207

Table 4: AGG Fund Style Analysis

Emerging Markets – VWO

The holding for the emerging markets position is Vanguard's Emerging Markets ETF. The fund tracks the FTSE Emerging Markets Index, holding large and mid-cap stocks in Brazil, Russia, India, Taiwan, China, South Africa, and others (*Vanguard FTSE Security Description*, 2015). The dominant allocations are to China (19.39%), Taiwan (14.49%), and India (12.64%);

all other holdings, including Brazil, South Africa, Hong Kong, Mexico, Malaysia, Thailand, and Indonesia, have less than 10% allocations (*Vanguard FTSE Allocation*, 2015). The table below further indicates that the fund is most correlated with stocks in North America, followed by Latin America and then positions in emerging Europe, Middle East, and Africa. All taken together, VWO seems to do a good job of representing an emerging markets position for the model.

Factors/Dates	5-Jan-15	3-Jan-14	8-Jan-13	9-Jan-12	10-Jan-11
MXAP Index (Asia Pac Stocks)	0	0	0.045	0	0.014
MXLA Index (Latin America Stocks)	0.35	0.559	0.373	0.223	0.464
MXNA Index (North America Stocks)	0.498	0.441	0.544	0.777	0.522
MSELEMEA Index (EM Europe/Middle East/Africa Stocks)	0.152	0	0.038	0	0

Table 5: VWO Fund Style Analysis

Developed Markets – EFA

The holding used in the model for the developed markets position is an ETF which tracks the performance of the MSCI EAFE Index (*iShares MSCI Security Description*, 2015). It holds large and mid-cap stocks in the developed countries, excluding the U.S. and Canada (*iShares MSCI Security Description*, 2015). Its top allocations are to Japan at 21.53% and the U.K. at 18.52% (*iShares MSCI Allocation*, 2015). All other allocations including to Switzerland, France, Germany, Austria, the Netherlands, Spain, Sweden, and Hong Kong, are less than 10% each (*iShares MSCI Allocation*, 2015). The table below shows that the fund is most correlated with North America stocks followed by Europe stocks, but still sees some correlation with Asia Pacific and Latin America stocks as well. Everything considered, EFA appears to be a good stand-in for the model for the developed markets position.

Factors/Dates	5-Jan-15	3-Jan-14	8-Jan-13	9-Jan-12	10-Jan-11
MXAP Index (Asia Pac Stocks)	0.074	0.119	0	0	0
MXEU Index (Europe Stocks)	0.236	0.052	0.245	0	0
MXLA Index (Latin America Stocks)	0.03	0.101	0.156	0	0.169
MXNA Index (North America Stocks)	0.66	0.728	0.599	1	0.831

Table 6: EFA Fund Style Analysis

U.S. Small-Cap – VB

The fund used to represent the small-cap position in the model is Vanguard’s Small-Cap ETF. This fund tracks the performance of the CRSP U.S. Small Cap Index, holding over 1400 mid and small-cap stocks focused in the U.S. and diversified across industries (*Vanguard Small-Cap Security Description*, 2015). The analysis of the fund’s style clearly reflects the fund’s description. The fund is most correlated with U.S. mid-cap growth and value stocks and U.S. small-cap growth stocks. This may cause some level of concern as it appears to be more correlated with mid-cap stocks than small-cap stocks, which is not what the ETF is intended to represent in the model.

Factors/Dates	5-Jan-15	3-Jan-14	4-Jan-13	9-Jan-12	10-Jan-11
SPTSX Index (Canada Stocks)	0.006	0.004	0.08	0	0.011
SGX Index (US Large Growth Stocks)	0	0.056	0.013	0	0
MIDG Index (US Mid Growth Stocks)	0.348	0.307	0.081	0.339	0.16
MIDV Index (US Mid Value Stocks)	0.256	0.219	0.255	0.182	0.218
SMLG Index (US Small Growth Stocks)	0.356	0.306	0.23	0.191	0.283
SMLV Index (US Small Value Stocks)	0.034	0.108	0.341	0.288	0.328

Table 7: VB Fund Style Analysis

U.S. Mid-Cap – VO

The position used to represent the U.S. mid-cap holding in the model is Vanguard’s Mid-Cap ETF. The fund tracks the performance of the CRSP U.S. Mid-Cap Index, investing in the stocks that make up this index in the same proportions as the index itself (*Vanguard Mid-Cap*

Security Description, 2015). The table below clearly indicates that the fund is indeed correlated with the mid-cap stocks in the U.S., both growth and value, but is also significantly correlated with U.S. large-cap stocks. This could be cause for concern as the fund is intended to represent only the mid-cap holdings within the model.

Factors/Dates	5-Jan-15	3-Jan-14	4-Jan-13	9-Jan-12	19-Jan-11	10-Jan-11
SPTSX Index (Canada Stocks)	0.031	0.016	0.034	0.009	0	0
SGX Index (US Large Growth Stocks)	0.317	0.173	0.115	0.206	0.172	0.19
SVX Index (US Large Value Stocks)	0.156	0.264	0.258	0.101	0.09	0.067
MIDG Index (US Mid Growth Stocks)	0.318	0.45	0.373	0.495	0.475	0.453
MIDV Index (US Mid Value Stocks)	0.177	0.04	0.218	0.189	0.263	0.291
SMLG Index (US Small Growth Stocks)	0	0.057	0	0	0	0
SMLV Index (US Small Value Stocks)	0	0	0.002	0	0	0

Table 8: VO Fund Style Analysis

U.S. Large-Cap – VTI

The fund used to represent the large-cap holdings in the model is Vanguard’s Total Stock Market ETF. This is the fund choice that initially triggered the concern over whether these choices were good matches for what they were intended to represent, as the title of the fund included “Total Stock Market” as opposed to “Large-Cap.” The VTI fund tracks the performance of the CRSP U.S. Total Market Index, holding stocks of all cap sizes in the U.S (*Vanguard Total Security Description*, 2015). Its aim is to represent the entire U.S. equity market, holding over 3500 securities (*Vanguard Total Security Description*, 2015). The table below shows that the fund follows this description, being correlated across the board of U.S. stocks. However, it is most correlated with large-cap growth and value U.S. stocks, lessening the concern that the fund is a mismatch for what it is intended to represent in the model.

Factors/Dates	5-Jan-15	3-Jan-14	4-Jan-13	9-Jan-12	10-Jan-11
SPTSX Index (Canada Stocks)	0	0.015	0.004	0.003	0.03
SGX Index (US Large Growth Stocks)	0.481	0.428	0.434	0.463	0.399
SVX Index (US Large Value Stocks)	0.34	0.357	0.386	0.379	0.428
MIDG Index (US Mid Growth Stocks)	0.078	0.089	0.092	0.082	0.097
MIDV Index (US Mid Value Stocks)	0.061	0.044	0.025	0.073	0.033
SMLG Index (US Small Growth Stocks)	0.034	0.041	0.004	0	0.014
SMLV Index (US Small Value Stocks)	0	0.026	0.054	0	0
USC0TR03 Index (US 3m LIBOR)	0.006	0	0.002	0	0

Table 9: VTI Fund Style Analysis

However, the fund’s description is clearly not aligned with what the fund is intended to represent in the model. An alternative would be to use Vanguard’s Large-Cap ETF (VV) to represent the large-cap position. This fund tracks the performance of the CRSP U.S. Large-Cap Index, holding the stocks that make up this index in the same proportions (*Vanguard Large-Cap Security Description*, 2015). The table below shows that this fund is even more highly correlated with the large-cap U.S. stocks than VTI, which aligns with the two funds’ descriptions. As such, this could be a better choice to use in the model to represent the large-cap holdings. That said, VTI is still dominantly correlated with the large-cap stocks and realistically functions well too.

Factors/Dates	5-Jan-15	3-Jan-14	4-Jan-13	9-Jan-12	10-Jan-11
SPTSX Index (Canada Stocks)	0.003	0.005	0.002	0.012	0.002
SGX Index (US Large Growth Stocks)	0.526	0.484	0.503	0.512	0.482
SVX Index (US Large value Stocks)	0.412	0.433	0.408	0.414	0.429
MIDG Index (US Mid Growth Stocks)	0.038	0.014	0.059	0.042	0.026
MIDV Index (US Mid Value Stocks)	0	0.036	0.003	0.017	0.039
SMLG Index (US Small Growth Stocks)	0	0.027	0	0	0
SMLV Index (US Small Value Stocks)	0	0	0.008	0	0
USC0TR03 Index (US 3m LIBOR)	0.021	0	0.017	0.003	0.022

Table 10: VV Fund Style Analysis

Results

The results from this project are two-fold. Firstly, I was able to help Robbie edit, refine, and update the back-testing of his investment policy. There were several cell formula errors that I was able to fix, thus allowing the Excel document to function properly. This also included correcting how the internal rate of return is calculated, allowing the model to better reflect the return on the hypothetical portfolio. When all the changes were accounted for, each model's rate of return increased by at least one percent. I was also able to think about some higher level questions for Robbie regarding his model. Accounting for transaction costs was reasoned to be unnecessary, and accounting for periodic rebalancing was deemed to be impossible using the model. Finally, each of the stand-in holdings was found to be a decent match for what it was intended to represent. The one that was furthest off, though still within bounds, was the one representing the large-cap holdings. In case a closer match was desired, an alternative was presented. All said, the goals Robbie set out for the project were accomplished.

The second piece of the project is what I was able to learn from it. I am going to begin working toward a career as a financial advisor when I graduate, and as part of being a financial advisor I will slowly develop my own investment philosophy. As I do so, I may want to back-test it to see if it actually produces better than average returns over time. In working with Robbie's model, I was able to see how I might go about doing so. I also gained further practice in gathering historical data on holdings, researching with Bloomberg, and analyzing funds to see if they actually perform according how they are intended to. In conclusion, I was able to learn some valuable skills for my future career while also getting to help Robbie with something important to his practice.

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