March 2016

Northfield News

A Newsletter for the Friends and Clients of Northfield

An Optimized Approach to Scenario Driven Risk Simulations

By Dan diBartolomeo

Introduction

This article provides a new approach to risk assessment from numerical simulations. As risk-related regulation extends from commercial banking to other parts of the financial services industry, risk assessments arising from "stress tests" and "scenario analysis" have become more widely discussed and implemented. Unfortunately, traditional methods for this kind of risk assessment are often counter-productive for long term investors who are not levered.

To resolve the shortcomings of numerical methods we have built a new process, extending the approach suggested in Meucci (2008, "Fully Flexible Views: Theory and Practice") which combines Monte Carlo simulations with the flexibility to overlay complex explicit scenarios. The analytical output of the process is a robust representation of the distribution of possible outcomes, while being consistent with any mathematically feasible "stress scenario."

For financial intermediaries such as commercial banks that are generally highly levered, the conception of risk is about ***solvency.*** The liabilities of the entity are current and subject to immediate call. The economic objective is to make as much money as you can each day while limiting the probability of going bankrupt to some acceptable level so you are likely to be in business tomorrow.

diBartolomeo *(2010, Journal of Investing)* found that the typical implied half-life of a financial firm is on the order of 20 years, but much shorter (e.g. 8 years) on a revenue

(Scenario, Continued on page 5)

Northfield's Headquarters is Moving

As of April 20, 2016, our Boston office will move to a new location directly on the Boston waterfront at Two Atlantic Avenue in the historic Pilot House complex.

The new location better accommodates required expansion of our IT infrastructure, while reducing our carbon footprint and providing closer proximity to the city's financial district. The building also offers a number of new amenities for Northfield staff and visitors, including underground parking, a full-scale fitness facility, private dock, and an on-site conference center.

The new address is:

Northfield Information Services
2 Atlantic Avenue, Floor 2
Boston, MA 02110

Special Points of Interest:

- Main Article: An Optimized Approach to Scenario Driven Risk Simulations
- Tech Tip: Running a Taxable Optimization
- Upcoming Events: Europe Seminar Series and the Newport Summer Seminar

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Recent and Upcoming Events

Northfield Europe Seminar Series – Research on Investment Management and Risk

London • Paris • Zurich

Northfield will be hosting three one day seminars in London, Paris and Zurich. The purpose of the seminars is to showcase our research on various topics in investment and risk management to our growing list of Europe Region clients and prospects.

London:

Wednesday, June 15, 2016 • Hyatt Regency London The Churchill

Paris:

Tuesday, June 21, 2016 • Hôtel du Louvre

Zurich:

Thursday, June 23, 2016 • Park Hyatt Zurich

Visit **http://www.northinfo.com/events.php** in the coming weeks to register. The full agendas will be posted as they become finalized. There is no cost for registering for any of the seminars.

Contact Mike Knezevich in London if you have any further questions., **+44 (0) 20 3714 4130** or e-mail: **mike@northinfo.com.**

2016 Newport Annual Summer Seminar

Tennis Hall of Fame • Newport, Rhode Island • June 3, 2016

Northfield's Annual Summer Seminar will be held at the International Tennis Hall of Fame in Newport, Rhode Island on June 3, 2016. The purpose of the seminar is to present recent research and technical advances to our clients and friends. Our meeting date has been selected to coincide with the US Professional Championships of Court Tennis. Following the day's presentations, there will be a Court Tennis demonstration by Northfield President Dan diBartolomeo, and then a Court Tennis match. Court Tennis, or "real tennis" is the medieval sport that is the progenitor of all modern racquet sports.

After tennis, there will be a relaxing oceanfront dinner party at the OceanCliff resort in Newport.

We will be accepting donations on behalf of the Pine Street Inn, Boston's largest homeless shelter for this event. The full seminar agenda and registration information will be posted to **www.northinfo.com/events.php** as it becomes available.

Webinar Wrap-up: Reconciliation of Default Risk and Spread Risk in Fixed Income

December 29, 2016 • 11:00 AM EST

Northfield President Dan diBartolomeo hosted a webinar on Tuesday, December 29th where he described the two conflicting concepts of what credit risk actually is. The classic definition which has to do with the likelihood that a given fixed income instrument will default (Probability of Default, PD), and the expected severity of economic loss in the event of a default (Loss Given Default, or LGD).

Dan reviewed the relevant approaches to credit risk, and illustrated how to reconcile the two views in order to satisfy the default risk concerns of "buy and hold" investors, while simultaneously explaining yield spread volatility for investors who are more concerned with controlling variation in period to period returns.

The presentation slides are available at **http://www.northinfo.com/documents/680.pdf.** Contact your Northfield Sales Representative if you are interested in viewing the full presentation recording of the event.

Webinar - Real Estate and Diversification, Part II

March 29, 2016 • 11:00 AM EDT

Northfield's Emilian Belev and Rick Gold will be hosting a webinar on March 29, 2016.

Abstract

In previous webinars, we focused our efforts on analyzing the correlation between real estate and other major asset classes. In particular, we examined the effects of appraisal bias on traditional correlation techniques and proposed methods to correct for these effects in order to extract private equity real estate's true inter-asset class correlations. The results revealed an unequivocal and statistically significant link between real estate and both stocks and bonds.

In this presentation, we will demonstrate the practical implications of our study to an investor pursuing an efficient diversification strategy. Specifically, we will employ a risk modeling approach with a robust historically observable relationship to both direct (illiquid) and securitized (REIT) real estate investments. To our knowledge, this is the first time that a strong empirical connection between these two asset classes can be demonstrated, despite the logical and practical desire to find such a link. The finding is even more noteworthy in view of the fact that the risk model used to connect the two asset classes is based only on real estate's fundamental characteristics, and neither commercial real estate indices and/or REIT returns were used as inputs.

We will also discuss the implications for hedging real estate from the perspective of a fund investor whose payoffs are based on appraised values (an open-ended real estate fund), as well as an investor whose payoff depends on the arm's length transaction of the underlying property itself.

Visit **https://northinfoevents.webex.com** to register. There is no charge to register. If you cannot attend the live session, please register and we will send you the post webinar recording.

Webinar Wrap-up: Rules-Based Style Rotation: Dynamic Switching between Smart Portfolios

February 23, 2016 • 11:00 AM EST

Northfield's Director of Research, Jason MacQueen, hosted a webinar on Tuesday, February 23rd, where he discussed a dynamic strategy of switching between a set of Smart Portfolio ETFs, with each capturing the returns to an individual Style. He focused on identifying the Smart Portfolio with the most consistent performance over the in-sample period, which is then taken to be a measure of the persistence of the corresponding Style factor risk premium. While this may not be the one with the highest returns, it is more likely to perform reasonably well in the next, out-of-sample period. The presentation illustrated this dynamic strategy over the past 10 years in the US market.

The presentation slides are available at **http://www.northinfo.com/documents/689.pdf**. Contact your Northfield Sales Representative if you are interested in viewing the full presentation recording of the event.

Webinar Wrap-up: An Optimized Approach to Scenario Driven Risk Simulations

January 28, 2016 • 11:00 AM EST

Northfield President Dan diBartolomeo hosted a webinar on Thursday, January 28th where he discussed a new approach to risk assessment from numerical simulations. Northfield has built a new process to resolve the shortcomings of numerical methods, extending the approach suggested in Meucci (2008) which combines Monte Carlos simulations with the flexibility to overlay complex explicit scenarios. The computational process involves an optimization problem that calibrates our "bootstrap" resampling process to one or more user defined scenarios. The analytical output of the process is a robust representation of the distribution of possible outcomes, while being consistent with any mathematically feasible "stress scenario."

The presentation slides are available at **http://www.northinfo.com/documents/687.pdf**. Contact your Northfield Sales Representative if you are interested in viewing the full presentation recording of the event.

Northfield Staff Profiles

Steven Dyer - Client Training and Support Specialist

Steven has been a member of the Client Service Group and support team since 2010, working directly with clients in training and continuing education in the use of Northfield's multifactor risk models, portfolio optimization software, and performance attribution analytics. He specializes in tax-aware optimization techniques and sophisticated optimization and portfolio construction methods.

Steven joined Northfield in 2009 as part of a research project to find a more predictive and effective metric for credit risk than the ones provided by the major ratings agencies. He has also been involved in research that has been reported on by the New York Times on the effectiveness of socially responsible investing.

Steven holds bachelor degrees in Biology and Spanish from Tufts University.

Richard Glidden (Dick) - US Sales and Marketing Team

Dick is part of the US sales and marketing team with particular focus on taxable private wealth managers, a client category Northfield has pioneered best practices within since 1997. Prior to his current focus, Dick has supported prospects and clients across the spectrum from asset owners, institutional and private wealth efforts over the past 15 years' at Northfield.

Dick joined Northfield in 2000 with 15 years' experience in both trading and modeling financial products. Positions included Vice President at The First National Bank of Chicago, Vice President at Lehman Brothers, Inc., Associate Director at Bear Stearns and Company, External Board of Directors Position at Aspen Strategic Alliance LLC and Business Development Manager at Chicago Investment Analytics, Inc. Previous responsibilities included client service, sales, marketing, management of derivative operations and quantitative alpha modeling. With his practical experience in the industry, Dick maintains a pragmatic perspective in the application of Northfield's services.

Dick has a B.A. degree from Michigan State University.

Alexey Lapin - Senior Software Developer

Alexey has been a software developer at Northfield since 2000. His responsibilities include Optimizer support and improvements, providing the API to clients, multi-platform functionality, development of the new Wealth Balancer stand-alone (Windows, Android, iOS) and web-based applications.

Prior to joining Northfield, Alexey worked as a programmer and web developer in Moscow for the largest information agency and a large commercial bank. He has approximately 20 years of experience in programming and computer science including a background in analysis, data modeling, design, development and implementation of RDBMS applications in a Windows based Client/Server distributed environment.

Alexey holds a Bachelor of Science in Applied Math.

(Scenario, Continued from page 1)
weighted basis, reflecting the higher leverage and complexity of large banks. For these organizations, risk is measured in value units (e.g. VaR, CVaR) and material effort is spent to get accurate prices for assets in order to assess net worth and leverage ratios as required for regulatory purposes. A similar but even worse circumstance exists for highly geared hedge funds as margin loans are at callable at will, *and* prime brokers have little incentive to worry about trading costs in a forced liquidation as long as net recovery is sufficient to cover the debt.

Sovereign wealth funds are the opposite end of the spectrum. Put simply, you can't go broke if you don't owe anybody any money. For long term unlevered investors, the key risk is ***the estimated variance of the future return stream.*** Consider that $1 invested for 50 years at a fixed 8% annually produces $46.90, while $1 invested for 50 years at an average 8% annually with a standard deviation of 20% produces only $17.42 in terminal value. The difference between the terminal values is a function of the time period and the variance (volatility squared) of the returns as illustrated in Messmore (1995, *Journal of Portfolio Management*). If higher moments are present in the return distribution you can adjust the volatility to account for skew and kurtosis. The relevant mathematics appears in Wilcox (2000, *Journal of Portfolio Management*). In this circumstance, *precision in current asset pricing is largely irrelevant.* If our true starting value were $.99 or $1.01 as compared to $1, the terminal values would only change by the same small proportion. Pension funds and insurance companies have liabilities but often only in an actuarial context, as the present value of expected future liabilities. These liabilities are generally not subject to immediate call.

For banks and other entities with liabilities at call, there are two common risk assessment practices. The first is Monte Carlo simulations of asset prices where there is random sampling from a parametric or empirical distribution to get a range of possible outcomes. Risk assessments are based on the lower tail of the portfolio value distribution. The second process is to forecast a single return value for a set or series of specific exogenous scenarios. For example "What will be the % change in the value of my portfolio *(notice it's a single point value)* if interest rates go up 2% and oil prices go down 30%?". It is widely argued that if we look at enough different "stress scenarios" we can gain an intuition about "worst case" outcomes. Unfortunately, the way most stress scenarios are formulated, their actual probability of occurrence is very, very small. Investors predicating investment strategy on such low probability outcomes end up with portfolios that are materially suboptimal in the vast preponderance of situations.

In May and September of 2006 we published newsletter articles describing the limitations of such analyses, and suggested fixes. Scenario based stress tests produced only a single point estimate outcome for each scenario. Even with many scenarios you can think of having estimated outcomes only for a small portion of the probability density. Again, financial strategies predicated on low probability events are sub-optimal the rest of the time. It's hard to live your life never crossing a street, although it may seem the safest course. Monte Carlo simulations just numerically get the distribution of portfolio values based on assumed underlying distributions. The risk assessments will not be much different than those from factor models widely used in asset management unless highly non-linear derivatives are involved. While there were many contributing causes, during the Global Financial Crisis all sorts of financial institutions from global banks to hedge funds became insolvent. All of these entities had elaborate risk systems, almost all based on numerical simulations as prescribed by banking and other regulators.

There are other conceptual issues associated with stress testing and scenario generation. Any ***scenario should be mathematically coherent, which is often a non-trivial exercise in conditional probability.*** In practice, many scenario processes represent a "partial equilibrium solution to a full equilibrium world." Let's assume that we have identified 50 economic drivers for the financial market of interest of which oil prices listed as Factor #1. If we hypothesize a 45% to 55% rise in oil prices, we must decide what is expected to happen to the state of the other 49 items. The likelihood that there would a big jump in oil prices and "nothing else would happen" is infinitesimal. As such, we must ensure that our expected range outcome for Factor #2 is consistent with the estimated correlation between Factor #1 and Factor #2. For a 50 factor model, there will be 1225 relationships that must fit together like the pieces of jigsaw puzzle. In addition, such "stress scenarios" are often *assumed to occur instantaneously,* which is implausible for most measures financial markets or real economic activity.

It is hard to simulate events that have never *yet* happened like the 1987 crash, "Flash Crash," or the August 2007 liquidity problem. To address such extreme events, concepts such as Chebyshev's inequality come in very handy. If the return of a portfolio is presumed to be normally distributed, the probability of an outcome that is worse than three standard deviations negative is about one in six hundred. However, if the shape of the probability distribution is entirely unknown, we can only assert that the probability of an outcome worse than standard deviations negative is not higher than one in nineteen, *roughly thirty times more probable* than under the normal assumption.

(Scenario, Continued on page 6)

(Scenario, Continued from page 5)

A Numerical Method We Like

Since the future is unlikely to be exactly like the past, we should be interested in whether the sequence of past events we have lived through is typical or unusual, given available history. As described in our June 2013 newsletter, our preferred numerical simulation method for exploring the distribution of a set of outcomes is "bootstrap" resampling. We can use bootstrap methods to answer the broader question of "what if things had been different?" but were drawn from a similar distribution for the set of factor return experiences. Rather than using the actual sequence of events (e.g. factor returns) we will be using many sequences of randomized events drawn from an historic set of experiences. In essence, we will assume that the future may follow *any one of an infinite number of paths that we might have experienced in the past.*

Mechanically, the process is easy and very, very fast. We use any of our risk models to get the factor profile of the portfolio at a chosen moment in time (e.g. now). Let's assume we want to make a period by period forecast of the return distribution for the next 12 months and that we have a 240 month history of factor returns. To create our first sequence of synthetic history as our forecast, we draw a random number N between 1 and 240. The factor returns for month N are now the first month of our first sequence of our forecast factor events. If we repeat the process 12 times, we will have one full sequence of potential future events. Note that since the choice is random each time, not only is the order of events randomized but some observations may be omitted and some observations may be repeated more than once. The probability of choosing each observation is 1/N at each draw. For each path we estimate the return on the portfolio for each observation period (e.g. month), assuming a random draw from the distribution of idiosyncratic risk.

Given the simple computational process, we can repeat this entire procedure many thousands of times in a few minutes to *produce a very robust estimate of the future distribution.* At each point in each path, we can calculate the estimated mean, volatility, cumulative returns, maximum drawdown, etc. We can also analyze the cross-section of paths at each projected moment in time to describe the period by period distribution of the statistics.

We can also account for serial properties in the return generating process. If we believe that asset returns are serially correlated, then fully randomizing the sequences will fail to represent this aspect of the data. To address this we can follow the procedure above, but build our sequences of future events from blocks of multi-month periods so as to capture most of the dependence from one month to the next. The length of the blocks would relate to the number of lags in an autoregressive process.

The Greek writer Agathon is remembered for his comment that "Even God Cannot Change the Past." It is true that so far, we are just sampling from an empirical distribution. There are several attractive properties to the process. Any of the paths we generate are plausible. All of the statistical relationships between factors would hold together. Most importantly, we can see how typical or atypical the actual sequence of history within the range of the paths we generate. The results are not a lot different than if we did Monte Carlo simulations that incorporated the higher moments and serial properties of the expected distribution. But the use of an empirical distribution at least ensures that effective distribution is realistic (it did actually happen).

However, a lot of things have changed since 450 BC. Even if we can't change the past *we can pretend that we can*, so let's try playing God. In terms of our risk simulations what we really want is to combine the rich distributional information of a numerical simulation with the "intuitive" nature of a set of explicit scenarios. Such a combined process is described in Meucci (2008) with extensions presented at a Society of Actuaries conference in March of 2015.

One way to "stress test" the projections by filtering the set of past observations from which our projected sequences are built. In effect, we are changing the "past" to only include periods of particular interest to us. We could include only months from periods of economic recession, or had rising interest rates or include only months that were perceived as particularly volatile. Meucci refers to this as "crisp conditioning." If we have a "seed sample" of N observations and we filter out P observations, the probability of any observation being drawn to fill a position in a particular path is *1/(N-P) or zero.* Now we have dense simulated data in both time series and cross-section, *conditional on the stressful or benign filtering.*

We can build further realism into our process by admitting that the probabilities of events may not be binary but continuous. To quote the poet, Kahlil Gibran "Who is to say that truth is in the crystal and not in the mist?". We can set up a more flexible process where the probability of any particular observation being drawn for inclusion in a bootstrap path is explicitly defined by the user. Instead of the probability of inclusion being 1/(N-P) we can choose a vector of explicit values for each observation in the seed sample. Each probability p_t must be between zero and one. The sum of all values of p_t must equal one. Meucci refers to this as *flexible conditioning.* While obviously feasible, it is not immediately obvious how an investor would decide what values should populate the probability vector.

(Scenario, Continued on page 7)

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Scenario Based Conditioning

At this point, we can introduce scenario based flexible conditioning. We would like combine bootstrap simulations with explicit scenarios. We can build the probability vector for inclusion of observations so as to fulfill the some explicit scenario within a confidence interval. For example, we could say "Do a bootstrap simulation where ***on every path***, the 10 year interest rate rises between 297 and 303 basis points, and oil prices decline 11 to 13% over a 12 month interval." Observations with increasing interest rates and declining oil prices would get more weight and vice-versa. Our scenario can specify any variable for which data exists for the seed sample. We are not limited to the factors of any underlying model. We can also generate several different scenarios and select the number of paths to be run for each to represent weights. We just do our cross-sectional statistics on the aggregated paths. A useful feature of this process is that *the cross-sectional variation in the paths is an implicit measure of the likelihood of the scenario.* If all paths are similar in their statistical properties, we know that the only a small fraction of all feasible paths fulfill the scenario.

Figuring out what probability vector best expresses a given scenario is a tractable optimization problem. We want to find the vector of probabilities such that all values of p_t are equal to or greater than zero. All values of p_t must also be less than one (one observation is obviously a degenerate solution). All values of p_t must sum to one. In addition, the attributes described in the scenario(s) are fulfilled within the prescribed ranges. Our final requirement is of paramount importance. We must preserve maximum randomness by minimizing the sum of the differences (absolute or squared) between each value of p_t and 1/N. It should be noted that if Northfield Optimizer is used to solve this problem, it will also come up with the closest possible probability vector if the scenario is infeasible within the range of outcomes of the seed sample.

In this new process, we use our regular risk models to get a representation of the portfolio and/or liabilities as a set of factor exposures. If needed, our SIENS simulation model within the EENIAC system can be used incorporate complex derivatives (via full repricing with translation to factor exposures). Unlike normal risk model usage, we represent not only variation around the mean return, but uncertainty of the mean return (see June 2013 newsletter). We use bootstrap resampling to compile a wide range of alternative simulations of history drawn from a seed sample of historical data.

The probability of any observation being included in a simulated path can be conditioned by filtering (crisp) or by a probability vector (flexible). The path driven simulations provide a rich set of statistical metrics in both time series and cross-section. For any feasible explicit scenario there exists a corresponding best probability vector. Multiple scenarios may be easily combined.

Conclusions

We have long held reservations as to the usefulness of "stress tests" and "scenario analysis" for financial institutions where day to day solvency is not the primary goal of risk management. Strategies based on low probability scenarios are sub-optimal for the vast preponderance of circumstances. Irrespective of our view, regulatory reforms in many countries are forcing more financial organizations to at least consider these concepts in their risk management process.

Combining our normal factor risk models, bootstrap resampling and scenario driven conditioning can provide a rich set of information about the potential distribution of future periodic or cumulative return outcomes over a short or long time horizon, in a way that can be more intuitive for fundamental investors. The new process is also very computationally efficient. Such a process will be incorporated within a range Northfield services in the near future.

Northfield on QUICK

You may have seen the news that our friends at FactSet have partnered with QUICK Corp., the Japanese financial information services company in the Nikkei Inc. Group. Great news for both FactSet and QUICK.

But that's even better news for our friends in Japan! With this window into FactSet on their terminals, QUICK customers can access anything that Northfield delivers via FactSet. That's a big list. FactSet has:

- Implemented Northfield's cross asset class risk model (Everything Everywhere) with extended asset class coverage to focus on risk compliance firm-wide for investment managers.
- Integrated the Northfield Optimizer for rebalancing portfolios containing all asset classes.
- Integrated all Northfield risk models for monitoring portfolio risk across all asset classes.
- Integrated the Northfield risk factor and factor return histories for monitoring portfolio performance.
- Applied the use of all Northfield products within their own backtesting product.

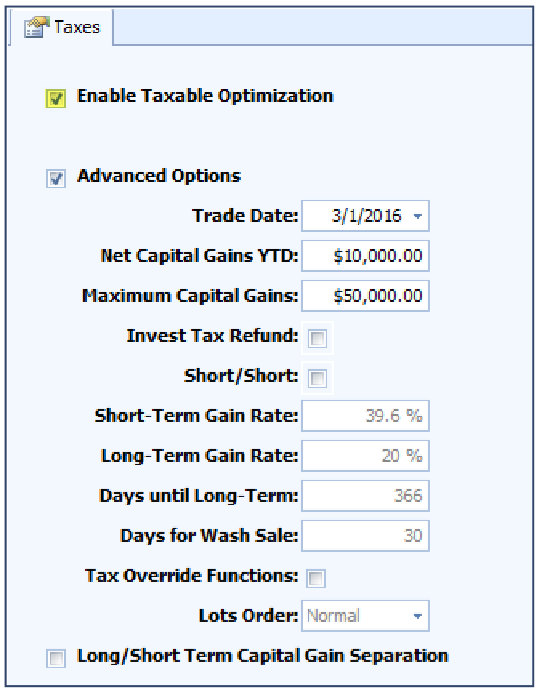
For more information, reach out to your Northfield contact or **sales@northinfo.com**.

Tech Tip: Running a Taxable Optimization in the Northfield Optimizer

By Steve Dyer

With the recent increased competitive pressure from so-called "robo advisors" introduced at many firms, it has become more important than ever for managers to provide tailored, sophisticated tax management solutions and strategies for their tax-aware clients. Fortunately, Northfield has had straightforward and comprehensive tax management features in our optimizer used by dozens of clients on hundreds of thousands of accounts since it was introduced twenty years ago. If you're new to setting up a tax-aware optimization, here's how to get started.

To set up a taxable optimization, the first step is to enable the taxable optimization option on the **Taxes screen**:



Enabling this option reveals a suite of settings and preferences for taxable optimizations. Most of the settings are straightforward. You can adjust the maximum capital gains you are willing to take in your portfolio and separate it into long term and short term gains, default tax rates, the amount of time until a short term tax lot becomes long term, and the assumption of the amount of time you need to wait until the wash sale no longer applies. "Invest Tax Refund" will add the value of a net tax lot to the value of your optimal portfolio. "Short/Short" will always apply short term tax rates to short positions, which is the correct behavior for investors in the United States. "Lots Order" specifies the accounting method for the order in which tax lots are sold. By default, lots are sold from least taxed to most taxed, but you can specify HIFO/LIFO/FIFO order as well.

Enabling taxes also changes the format of the portfolio file:

Portfolio

	ID	ShLots	Price	Date	SerialNo
1	AAPL	2000.0000	113.68	2010/01/01	APPLE
2	AAPL	1000.0000	90.52	2015/04/01	APPLE
3	AAPL	500.0000	101.05	2012/07/01	APPLE
4	MSFT	2472.0000	57.14	2011/02/01	MICROSOFT
5	MSFT	3000.0000	47.16	2011/12/01	MICROSOFT
6	MSFT	-999.0000	55.02	2016/03/01	MICROSOFT

With taxes enabled, additional columns appear to specify the purchase price/cost basis and the date on which each lot was purchased, as well as an optional field for a user-specified serial number. By comparing the purchase price to the current price specified in the exposure file or price file and the purchase date to the date of optimization, the optimizer can calculate the amount of long term or short term gains embedded in each lot.

The reserved value "-999" for number of shares is used to represent lots that have recently been sold and are no longer held in the portfolio to prevent the violation of the wash sale. These "-999" entries will appear in the optimal portfolio output for future optimizations, or simply add in your recent sales with the date they were sold and the optimizer will automatically prevent trades that will violate the wash sale.

The optimizer translates the tax costs for each lot into a *transaction cost* to be used in the utility function during optimization so that the proper trade-offs between return, risk, and trading costs will always be considered for each trade. Recall that the utility function in the optimizer is

Utility = Return – Risk – Costs – Penalties

Or more formally

$$U = \alpha - \left(\frac{\sigma_s^2}{RAP_s} - \frac{\sigma_u^2}{RAP_u}\right) - ((C+T*A) - (\text{scale}*\text{distance from goal}^2)$$

where

α = outperformance per year

σ_s^2 = factor variance

RAP_s = factor risk acceptance parameter

σ_u^2 = stock specific variance

RAP_u = stock specific risk acceptance parameter

C = transaction costs as a percent of the transaction

T = Tax costs as a percent of the transaction

A = amortization value

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For taxes, we are concerned with the value of T in this equation. A tax *loss* will be a *negative* transaction cost and an *increase* in utility. A tax *gain* will be a *positive* transaction cost and a *decrease* in utility. The practical and obvious outcome of this is that the optimizer will seek to sell lots with the largest losses first and avoid selling the lots with the largest gains. Tradeoffs between risk, return, and costs are calculated in an intuitive and straightforward way – if a stock has $10 of tax benefit in losses, but the alpha provided says that it will return $20 over the next year, it will not be sold since 20>10. Unless the lot order accounting method is specified, the optimizer will automatically choose to sell lots of each security in the most beneficial order, starting with the least taxed/largest loss and ending with the most taxed/largest gain. The order of lots can be investigated more thoroughly in the optimization log **(http://www.northinfo.com/docs/tech0314.pdf).**

Further, if a lot is currently short term, the opportunity cost of waiting for it to turn long term is factored in. If a stock is at a short term gain and being considered to be sold, waiting for it to turn long term will allow us to permanently avoid paying a higher rate of taxes and a lower tax bill. Similarly, if a stock is held at a loss and about to turn long term, we are more inclined to sell it before it turns long term to be able to bank the larger amount of losses. Here is an example of how this is treated by the optimizer:

A stock is trading at $35.

The optimization is done on March 1, 2016.

The short term tax rate is 40%.

The long term tax rate is 25%.

Amortization is set to 100%.

Lot 1 was purchased on 3/1/2012 at $31

Lot 2 was purchased on 3/4/2015 at $34 (this lot will go from short term status to long term status in 3 days!)

The % tax cost for selling Lot 1 is (35-31) = $4 * 25% * 100% / 35 = $1/35 = **2.85% cost per year**

The % tax cost for selling Lot 2 is [(35-34) * 25% * 100% + **(35-34) * 15% * 365/3**] / 35 = **16.96% cost per year**

The portion in red is the extra tax that the user can permanently avoid by waiting just three days to sell that lot. If we have to sell some stock today it makes sense to sell Lot 1 now so we can hold on to Lot 1 for 3 more days and avoid the extra 15% tax (40%-25%) altogether.

Capital Gain Limits, Loss Harvesting, and Loss Carryforwards

The optimization also takes into consideration the amount of total capital gains or losses that have been taken. Because of the way that tax costs are represented in the utility function, the default behavior will be to harvest losses and avoid gains, as gains will increase tax burden and losses will decrease the tax burden. The natural consequence of this behavior is that loss carryforwards are created when more losses are harvested than gains. The value of a loss carryforward to a portfolio manager can be a matter of preference and circumstance – some will want to always harvest all losses available, while others do not believe loss carryforwards to be valuable and would want to set tax rates to zero when there are net negative capital gains (while still trading for alpha or risk reasons).

The optimizer uses a compromise view. When the optimization is in a net negative capital gains position, inclusive of year-to-date gains or losses and the current optimization, the tax rate of positions at a loss is set to zero in the utility calculations, while positions at a gain are taxed at the normal rate. This makes the optimizer *indifferent* towards taking further losses instead of actively seeking to harvest them, while still avoiding taking further gains. We assume that if we have cumulative losses, we shouldn't take further losses just for tax reasons, but we may do so for other reasons, such as alpha, risk or constraints. On the other hand, even if we have cumulative losses, we assume we should still avoid taking gains.

The Maximum Capital Gains setting is a stopping constraint. If an optimization reaches this amount of net capital gains, it simply stops trading.

Altering the Default Tax Behavior

There are scenarios when managers might want to change the default tax behavior of the optimization for their clients – perhaps the client has a large capital loss outside their portfolio and wants to harvest gains and avoid losses, or wants to aggressively harvest all available losses. There are easy techniques to accomplish both.

If you want to aggressively harvest all losses even when the portfolio has net losses, you only need to set the Net Capital Gains Year To Date value to be a large number relative to the size of the portfolio. This will prevent the optimization from entering the net negative capital gains space and allow the optimization to continue seeking to harvest losses.

As negative tax rates are not allowed, to flip the behavior completely and harvest gains and avoid losses, enable the Tax Override function. This enables two more fields in the

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portfolio file, the Adjusted Cost Basis and Adjusted Purchase Date:

Portfolio

	ID	ShLots	Price	Date	SerialNo	Price(Adj)	Date(Adj)
1	AAPL	2000.0000	113.68	2010/01/01	APPLE	105.26	2015/01/01
2	AAPL	1000.0000	90.52	2015/04/01	APPLE	105.26	2015/01/01
3	AAPL	500.0000	101.05	2012/07/01	APPLE	105.26	2015/01/01
4	MSFT	2472.0000	57.14	2011/02/01	MICROSOFT	55.48	2015/01/01
5	MSFT	3000.0000	47.16	2011/12/01	MICROSOFT	55.48	2015/01/01

The optimizer will use the adjusted values during the optimization, but use the actual values in all reporting. This allows you to "trick" the optimizer into treating gains as losses, losses as gains, and long term as short term and vice versa in any combination or magnitude you require.

If you have further questions about Taxable Optimization, please contact Northfield Technical Support. In Boston, 617.208.2080, **support@northinfo.com.** European clients can contact: **support-europe@northinfo.com** or call +44 (0) 17 2244 RISK. In Asia, call +81(0)3 5403 4655 or +61(0)2 9238 4284 or **support-asia@northinfo.com.**

Northfield Partners with SSGX

Northfield is partnering with State Street Global Exchange (SSGX) , a part of State Street Bank and Trust Company, to integrate Northfield's risk models and other product offerings to enhance the risk reporting capabilities currently delivered by SSGX to its custodial, asset management and hedge fund clients globally. SSGX will provide a more detailed announcement regarding the nature of the relationship and timing of the joint product offerings later in the spring.

Staff Speaking Engagements

Northfield President Dan diBartolomeo discussed "Organizational Behavior in Risk Management" at the FRA Performance and Risk Conference in New York City on February 22nd. Northfield's Emilian Belev was a panelist for the "Measuring Performance and Risk of Alternative Investments" discussion at the same event.

Dan presented "Risk Management for Public Pension Funds" at the New York City Society of Actuaries Investment Symposium on March 14th. Dan was also on the program committee and served as the moderator for two additional sessions.

On March 15th, Dan spoke at the Boston QWAFAFEW meeting. The topic was "Making 'Robo-Investing' Work: Key Requirements."

Dan will be at the Pensions and Investments Epic Conference in Half Moon Bay, California, on April 17th. He will be presenting "Backtesting: Useful Tool or Financial Charlatanism.

Dan will be discussing "Organizational Behavior Effects in Investment Risk" at the Performance Measurement, Attribution and Risk (PMAR) Conference in Philadelphia on May 17th.

On March 10th, Northfield Asia's Nick Wade presented "Risk Systems that Read" at the Sentiment Analysis in Finance Conference in Singapore.

Northfield Research Director Jason MacQueen, has presented his latest talk, "Rules-based Style Rotation: Dynamic Switching between Smart Portfolios," at several recent industry events including:

- The INQUIRE UK Practitioner Seminar in London on January 20th.
- The inaugural QWAFAFEW Seminar in Edinburgh on January 21st.
- At a Rutgers Seminar in Newark, New Jersey on February 11th.

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