



*Best Practices for Computer Models for
Portfolio Planning*

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The passing of the Pension Protection Act of 2006 (PPA2006) could very easily signal a major advancement in the tools that investors have available for investment planning through their retirement plans. A wide variety of sources have documented that individual investors in self-directed retirement plans such as 401(k)'s need far more specific and personalized advice for planning than they have been receiving. The PPA2006 supports the provision of specific investment guidance using computer models to ensure objectivity:

*“Under the new law, beginning in 2007, plan sponsors will be able to offer fund-specific investment advice to their plan participants through their retirement plan provider or other fiduciary adviser. **Such fund-specific advice may be made available using a computer model that is appropriate for retirement investing and is certified and audited by an independent third party.**”*

<http://biz.yahoo.com/prnews/060817/sfth084.html>

What should such a ‘computer model’ look like, and what sort of certification and auditing will be needed? This is a key question and I believe that it is possible to establish a reasonable and pragmatic set of standards that such models must meet. This is not a purely theoretical exercise, however, because I believe that our portfolio planning tool, ***Quantext Portfolio Planner (QPP)***, is a good example of best practices for personal portfolio planning both at relatively near-term horizons and in the long-term (i.e. to retirement).

Whether or not you are an individual investor looking for better planning tools or a 401(k) provider looking for good candidates for a computer model to provide to plan participants, establishing the standards that a computer model must meet is of great importance. The following table shows a hierarchy of requirements for a suitable computer model, in increasing difficulty.

Requirement	Impact if not satisfied
<i>Analysis must be probabilistic: Level 0</i>	Results will not account for impacts of uncertainty in future performance.
<i>Analysis must be ticker specific: Level 1</i>	Model will not help in distinguishing between specific individual stocks and funds. Different funds and stocks within a sector or style may have very different risk, return, and fees.
<i>Must generate forward-looking inputs for individual assets: Level 2</i>	Backward-looking analysis leads to sub-standard results (e.g. Bernstein study cited herein).
<i>Must account for diversification effects: Level 3</i>	Tools that do not account for both systematic and non-systematic correlation properly will tend to under-estimate portfolio risk so that realized volatility will tend to be higher than model forecasts
<i>Must support model audits: Level 4</i>	Lack of transparency means basic testing and validation is impossible
<i>Must meet standard reporting requirements: Level 5</i>	Models that do meet basic reporting standards will lead to less effective decisions

Analysis must be probabilistic: Level 0

The most fundamental requirement for appropriate computer models is that they are probabilistic, which means that they account for the uncertainty in future performance (i.e. risk) associated with portfolio assets. Probabilistic models in these applications are most often what are called Monte Carlo models, which means that they are simulation models that generate many possible future portfolio outcomes and then calculate confidence levels regarding future portfolio value and the ability to fund retirement at a required level. Models that do not account for risk cannot be considered to meet even a reasonable standard of practice.

The output from a Monte Carlo model will typically provide the probability of being able to fund retirement for a certain number of years. The basic output will show the

probability that you will run out of money by a certain age in retirement, given the basic inputs.

The fact that a software tool applies a Monte Carlo approach tells you very little about the quality of the system. While popular articles on Monte Carlo tools often throw the term around as though ‘Monte Carlo model’ were a generic term, there are enormous differences in the viability of different frameworks.

QPP is a Monte Carlo simulation model that calculates funding survival rates in long-term but also provides a great deal of near-term decision support. The ability to examine specific future time horizons allows investors to effectively determine how much risk they are comfortable with.

Analysis must be ticker specific: Level 1

Investors need Monte Carlo tools that allow them to develop portfolio allocations in terms of ***specific holdings***. The quote at the start of this article about the Pension Protection Act specifically notes the need for ‘fund-specific’ advice, as opposed to generic allocation advice. I will take this a step further. Given that many retirement plans include company stock as an investing alternative, I will simply propose that the best practice is a Monte Carlo tool that can support allocations into ***individual stocks*** as well as mutual funds. Monte Carlo planning tools that provide fund-specific advice must also be able to properly account for all fees associated with a mutual fund. The ability to properly account for fees is often cited by experts (such as Vanguard’s John Bogle) as one of the most critical steps in choosing investments, so this capability is requisite.

QPP supports portfolios that contain individual stocks, mutual funds, and ETF’s and accounts for total fees associated with each individual fund, with the exception of loads and redemption fees.

In a survey of 401(k) plans, Vanguard found that about 70 percent of participants in plans that included company stock as an alternative had more than 20 percent of their assets invested in their employer's stock. To be effective, planning tools should allow investors to account for these assets along with the choices of mutual funds within a 401(k) plan.

Requiring Level 1 to be satisfied removes most of the available 'Monte Carlo' tools and related probabilistic tools from consideration. Many computer models require the user to specify the average return and standard deviation of return on a hypothetical portfolio or simply simulate portfolio performance in terms of allocations into generic asset classes (stocks, bonds, etc.) rather than specific stocks or funds. Some of the available tools that appear to be able to analyze individual funds and stocks accomplish this simply by categorizing a fund or stock into a 'class' and then simulating that class. In these models, any two large-cap stock funds may end up giving the same portfolio impact even if they have very different dividends, returns, and volatilities over their histories.

Must generate forward-looking inputs for individual assets: Level 2

Models that pass ***Level 0*** and ***Level 1*** requirements are probabilistic and can support portfolios of any assets which have a ticker symbol, be it stocks, mutual funds, or ETF's. Passing this requirement set leads to the next hurdle. The fact that a computer model can, in principle, support individual tickers does not mean that the model has the ability to properly generate descriptive statistics for the assets. In the world of professional risk management, the process of generating the statistical inputs to describe portfolio components is called ***parameterization***. Computer models for portfolio planning depend on having good inputs. A great Monte Carlo simulation with bad inputs will yield unrealistic results.

Monte Carlo or other probabilistic computer models that require the user to specify all of the inputs for assets immediately fail ***Level 2*** standards. Similarly, computer models that simply lump assets into style classes will fail because their inputs can be far from realistic, as noted in the last paragraph. To be useful to individual investors and their

advisors, a computer model must be able to generate a default set of parameters that are ticker-specific and pass some standards of validation.

Quantext Portfolio Planner (QPP) generates ticker-specific parameters automatically for any asset with a ticker. We spend a great deal of time devising tests for the validity of the input parameters. The most basic inputs for a stock or fund are the projected future average return and the projected future standard deviation in return. QPP combines recent market history for a ticker with long-term relationships between risk and return in capital markets to perform a process called risk-return balancing. While the period can be adjusted, the default near-term historical period is three years. Using the trailing three years, we project future volatility for a stock or fund. The future volatility is then used to project future average return by applying the long-term balance of risk and return. The resulting projections for future average return and standard deviation in return can be quite easily tested. We have performed numerous statistical studies that show that both our projected volatility levels and projected average returns are a far better basis for portfolio planning than using trailing historical data alone. This is an important benchmark because some of the available Monte Carlo tools simply assume that the future will look like the history from 1-10 years behind, despite the fact that this approach tends to lead to bad decisions. The very poor investing outcomes from directly using historical results as the prediction of future performance have been outlined very succinctly by Bernstein in *The Intelligent Asset Allocator*. His results show, for example, that allocating a portfolio based on trailing five-year asset performance would yield returns that were half of what a simple static policy portfolio would return.

The types of tests that are appropriate for testing the validity of inputs include the following:

1. Testing out-of-sample projected average returns
2. Testing out-of-sample projected standard deviation in returns
3. Looking at specific historical 'stress tests.'

4. Comparing projected standard deviation in return to implied volatility in options markets

These four classes of validation tests are not new—they are standard practice in tests of professional portfolio management software. The first two types of tests listed above are quite easy to explain. You allow your model to have access to historical data up to a certain date in history and then you simulate forward from that date. You then compare the predicted average and standard deviation in returns to what actually happened. QPP has been tested in this manner in a variety of cases. In a recent article in which we analyzed out-of-sample performance over ten three-year periods through 2005, we found that the error (mean absolute error) in predicted average annual return for the NASDAQ 100 index was half of the error from using the trailing three years as an estimate of future average return. We also found that the projected future standard deviation in return from QPP was substantially more accurate than using the trailing volatility. This article is available on our website: <http://www.quantext.com/PerformancePredictionQQQQ.pdf>. We have performed similar analysis for a variety of other cases. QPP allows this type of test can be easily reproduced by any user for any assets.

The third class of test is also easy to explain. Users often want to know what a tool would have told them about a stock, fund, or total portfolio just prior to a specific event. It is most often the case that this is a very bad event and this approach is called *stress testing*. I have analyzed a number of these cases, including tech portfolios prior to the collapse of the tech bubble, the 2006 emerging markets decline, and the major decline in the Nikkei in the early 1990's. In the case of the 2006 emerging markets decline, we published results from QPP in an article warning that investors were under-estimating the potential for loss before the decline. Representative articles on these issues are available here:

Emerging Markets in 2006	http://www.quantext.com/TechvsEmerging.pdf
Tech Bubble in 2000	http://www.quantext.com/BubblePortfolio.pdf

The fourth class of tests listed above is a bit harder to explain. One of the key factors in a probabilistic simulation is how volatile a given asset will be—indeed this is the point of using a probabilistic model. A standard approach in testing probabilistic models in capital markets is to use the model to price options on the underlying. The price of an option depends strongly on the projected future volatility so comparing options prices generated by a probabilistic model to current market quotes means allows you to compare the volatility in the model to the market consensus volatility implied by options prices. Further, it has been repeatedly shown that the implied volatility in options prices is a good predictor of future volatility. For an overview of this process, see the following article: <http://www.quantext.com/SPYandEEMVolatility.pdf>. This article includes citations in the literature about the value of implied volatility as a prediction of future realized volatility. This type of testing for Monte Carlo models and other probabilistic models is generically referred to as mark-to-market testing. We have performed a series of validations for options prices on index ETF's and individual stocks and we have found consistently high agreement between QPP results and current quotes. This means that QPP's projections of future volatility are consistent with market implied volatility. Representative papers are shown below:

SPY and EEM Tests in August 2006 <http://www.quantext.com/MarketRisk3.pdf>

SPY and QQQ Tests in January 2006 <http://www.quantext.com/RiskOutlook2006.pdf>

MSFT Tests in September 2005 <http://www.quantext.com/Stock%20Options.pdf>

The third paper listed above also provides additional background on basic option pricing theory and applications in QPP and QRP.

The mark-to-market testing for the volatility generated by a Monte Carlo model for portfolio planning and retirement planning should emerge as a part of best practice. It is not required that the models match the market implied volatility too closely, but the general level of volatility should be consistent.

Must account for diversification effects: Level 3

Very few models will meet the requirements laid out in *Levels 0 to 2*. For those that do, the next level of validation is looking at how the computer model accounts for the correlation between portfolio components. The correlation in performance between assets in a portfolio determine the level of diversification. A well-diversified portfolio protects the holder from extreme swings in any individual asset class. Without a good computer model, investors lack quantitative measures of diversification and thus have little objective basis for assessing diversification. Ultimately, a well-diversified portfolio allows the holder to achieve the most return available for a given level of total risk.

Even if you can simulate the individual portfolio components with a high degree of confidence, you cannot simulate the performance of the total portfolio unless you can also account for the correlation between portfolio components. The relationships between portfolio components determine the level of portfolio diversification and capturing these effects properly is a crucial component of portfolio modeling. Assets that are less well correlated will result in a better portfolio than assets that are well correlated, other things being equal. While the idea is simple, the effective implementation is not trivial. There are two basic sources of correlation between assets in a portfolio. Both are important, but one of them is often missed.

The first component of correlation is *systematic correlation*. Systematic correlation between assets is due to the fact that many assets are correlated to the broader market. Any two funds that are correlated to the market are also correlated to each other. Many investors are acquainted with this measure of correlation through Beta. Two funds with positive Beta will be correlated to one another. It is relatively straightforward to account for systematic correlation.

The second, and more challenging, source of correlation is *non-systematic correlation*. There are many cases in which portfolio components may exhibit low correlation to the broader market but be highly correlated to one another. A well known case is energy and utilities stocks. Utilities tend to have low correlation to the market as a whole but can be

very highly correlated to one another. This phenomenon also shows up in other commodity-driven sectors. Non-systematic correlation is especially important if you happen to have multiple investments in overlapping stocks or funds. There is very often some style overlap between funds that requires that you account for non-systematic correlation. Any type of concentrated focus in a given sector, including something as benign as multiple fixed income investment vehicles, will require good treatment of non-systematic correlation in order to provide a good estimate of total portfolio risk.

Quantext Portfolio Planner accounts for both systematic and non-systemic correlation. As I noted above, the non-systematic component is harder to account for. For details and demonstrations of how QPP captures non-systematic correlations and risk, along with examples using another standard approach called *Style Analysis*, see the following article:

<http://www.quantext.com/TrueDiversification.pdf>

As the article above discusses, methods used commonly in Monte Carlo simulation tools may not account for non-systematic correlation effectively. If you don't account for these correlations, you will tend to under-estimate total portfolio risk—sometimes substantially.

Must support model audits: Level 4

The Pension Protection Act has several comments stating that an acceptable computer model needs to be checked out by a qualified individual. This feature of a computer model is best described as *auditability*. To be auditable, a qualified investment advisor (such as a Registered Investment Advisor) must be able to perform the tests described in *Level 2* using a standard version of the software. QPP fully supports this capability. Further, it is very straightforward to audit QPP's ability to capture both systematic and non-systematic correlation between portfolio components using a standard version of the software (as described in the article linked in the discussion of *Level 3*).

Must meet standard reporting requirements: Level 5

The quality of reporting and performance measures that a computer model provides are a critical factor in determining the ultimate value of the tool in making better decisions. Standard metrics and measures that a tool would provide to be in line with standard financial practice in finance and risk management would be:

- 1) Portfolio average return
- 2) Portfolio standard deviation in return
- 3) Portfolio Beta
- 4) Portfolio dividend yield
- 5) Projected median portfolio value in time
- 6) Projected percentiles of portfolio value in time
- 7) Probability of portfolio survival by age in retirement
- 8) Probability of performance levels at intermediate time periods (months to years)

These eight statistical outputs are all standard financial measures of a portfolio for long-term planning. QPP reports all of these measures. Each of these measures provides unique information about the way that a portfolio is likely to behave in the future. The lack of any one of these measures diminishes the ability to judge the portfolio.

Summary

The Pension Protection Act of 2006 (PPA2006) provides an impetus for the application of computer-based asset allocation and planning tools. These tools have been widely available in various forms since the late 1990's for portfolio planning, but adoption has been fairly slow. PPA2006 will help to spur to use of these computer models in 401(k) plans, which has the potential to provide enormous assistance to individual investors and financial advisors as long as the tools that are used meet certain quality criteria. While the PPA2006 provides some general statements as to the necessary standards for these tools, I have tried to provide an explicit list of requirements that are consistent with the

intent of PPA2006 and with standards of practice in simulation and risk management. ***Quantext Portfolio Planner*** robustly satisfies all of these requirements. Due to the *auditability* built into the software, any user can perform such tests themselves.

More information on Quantext Monte Carlo planning tools, as well as a free trial, is available at: <http://www.quantext.com/gpage3.html>