Vanguard Global Capital Markets Model

Research brief

March 2015

Vanguard's Global Capital Markets Model™ (VCMM) is a proprietary financial simulation engine designed to help our clients make effective asset allocation decisions. The model is also used as the basis for Vanguard's global capital markets outlook.

The VCMM has two main elements:

1. a global, dynamic model that simulates return distributions on a wide array of asset classes; and
2. an asset allocation tool to help construct portfolio solutions.

This brief examines the characteristics of the asset return simulation model and how its forward-looking return projections can be applied in the portfolio construction process.

What is the Vanguard Global Capital Markets Model?

The Vanguard Global Capital Markets Model simulates forward-looking asset return distributions for a range of asset classes and risk factors. Examples of VCMM asset classes include cash, bonds, equities, and commodities; while examples of risk factors include inflation, yield curves, and volatilities.

The VCMM enables clients to measure the potential portfolio outcomes when using different asset allocations, taking into account different market conditions and risk and return factors.

Why do investors need model-based financial simulations?

Investors primarily construct portfolios using a top-down approach to asset allocation, that is, starting with the big picture. Asset allocation relies on a broad analysis of capital markets and requires a thorough understanding of the key economic and financial drivers of asset returns. Quantitative models can deliver consistent asset return expectations and realistic projections of volatility and diversification across different asset classes.

Traditional models, such as time-pathing and basic Monte-Carlo stimulations, are limited as they forecast return distributions from historical asset class returns. However, interpolating only the past mean we become slaves to history.

The VCMM uses a multi-faceted approach to simulation, combining historical data of economic and financial drivers with Monte-Carlo methods. The output of this combination are asset return expectations and distributions. The VCMM offers a more holistic approach to asset return simulations by:

- incorporating current market conditions and correlation of asset returns
- forming forward-looking return forecasts based on capital market equilibrium
- taking into account non-normal distributions
- using current prices for market assets to generate expectations of market consensus

The VCMM framework

The key principle of the VCMM is that asset returns are compensation for the systematic risk (or beta) of that asset class.

The VCMM uses historical macroeconomic and financial market data to dynamically model the return behaviour of asset classes. It includes variables such as yield curves, inflation and leading economic indicators. The model estimates the dynamic statistical relationship between risk factors and asset returns using historical data dating as far back as 1960. It then uses Monte-Carlo regression analysis to predict these relationships into the future.

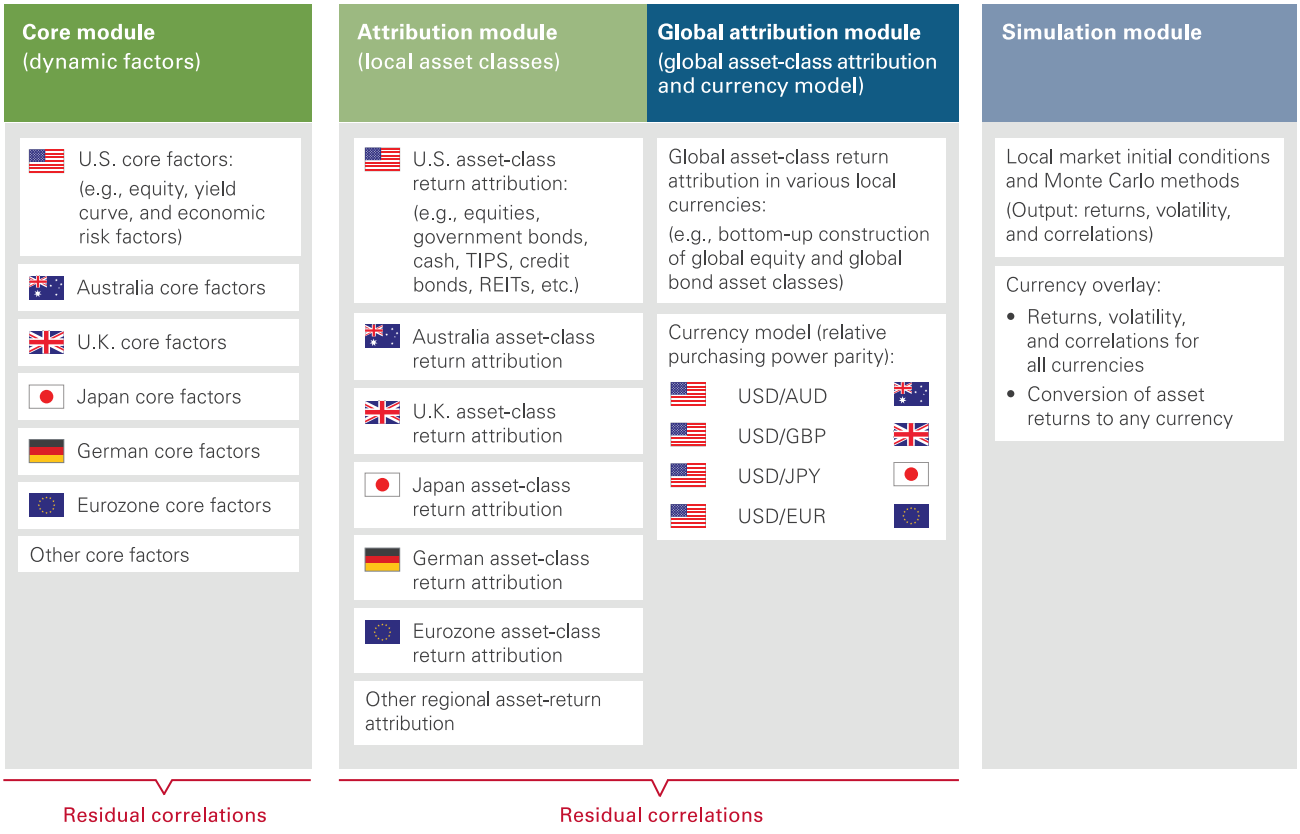
The four modules of the VCMM are shown in **Figure 1** and described below.

Module 1: Core module

- a dynamic model of various macroeconomic and financial risk factors or drivers.

This module determines the relationship between the core macroeconomic and financial risk factors in each region over time using a statistical model called vector auto-regression (VAR).

Figure 1 The four modules of the asset return simulation model in VCMM



Note: Regions modeled by the VCMM—normally modeled as market-capitalization weighted—were chosen to capture the vast majority of capital markets and to help answer portfolio questions from Vanguard clients.

Source: Vanguard.

The VAR technique models three main categories of risk:

1. Local equity factors are the core drivers of asset prices and are strongly linked to the performance of domestic equity markets.

2. Local fixed income factors, which include yield curves for government bonds. The yield curves cover the entire term structure (from a quarter to 30 years) and are based on the dynamic relationship between economic activity and inflationary expectations.

3. Local economic factors, which include inflation and proprietary leading indicators of economic activity and fluctuations in local business cycles.

Module 2: Local attribution module

- links local asset class returns with regional risk factors.

This module uses regression analysis based on regional risk factors from the core module to map asset class returns.

Module 3: Global attribution module

- models global asset class returns based on a combination of regional returns or global core factors, including currencies.

This module constructs asset return benchmarks, such as global bonds or global equity indices. It includes foreign exchange markets, so asset returns can be translated between currencies.

Simulation module

- combines statistical relationships using regression-based Monte Carlo to generate a range of potential future returns.

This module generates scenarios, or potential future outcomes, for all the risk factors and asset classes in the above modules. It uses a regression-based Monte Carlo approach to generate a range of return paths rather than single point forecasts. This simulation technique allows for a dynamic range of asset class returns that revert to a long-term steady state. These steady state projections are based on historical estimates of long-term economic and financial factors, which are then tempered by qualitative judgment.

The outputs from this model can be summarised into reports showing key statistics such as means, medians and standard deviations for the different asset class returns across a wide variety of time periods.

Global capital markets equilibrium

The global capital markets equilibrium is built into the VCMM and plays a key role in formulating asset return expectations that are forward-looking and not reliant on any specific choice of data sample. It provides a qualitative overlay, which represents Vanguard's best thinking of how global capital markets should operate over the very long term under normal conditions.

Limited historical data sets can lead to biased projections of future asset return expectations. This bias can be misleading and result in inadequate portfolio allocation. The VCMM counters this limitation by replacing historical averages with alternative forward-looking capital markets equilibrium assumptions. This replacement means that the simulated variables revert towards the equilibrium rather than historical average values.

The calibration of equilibrium conditions for long-term risk factors combines historical data with a theoretical framework.

Other features of the VCMM

Another important feature of the VCMM is its ability to model currencies as an overlay to asset returns, rather than a risk factor. This overlay means the asset return projections do not depend on currency factors, they are just denominated in a given currency. The model can easily translate asset returns between currencies, which is vital for the bottom up construction of global asset return benchmarks.

Figure 2 shows an example for the simulated projections for the USD/AUD market. The median forecast, as shown by the red line, matches the exchange rate implied by the interest rate differential between two countries at different maturities. This implied rate can be viewed as the market expectation for future spot exchange rates.

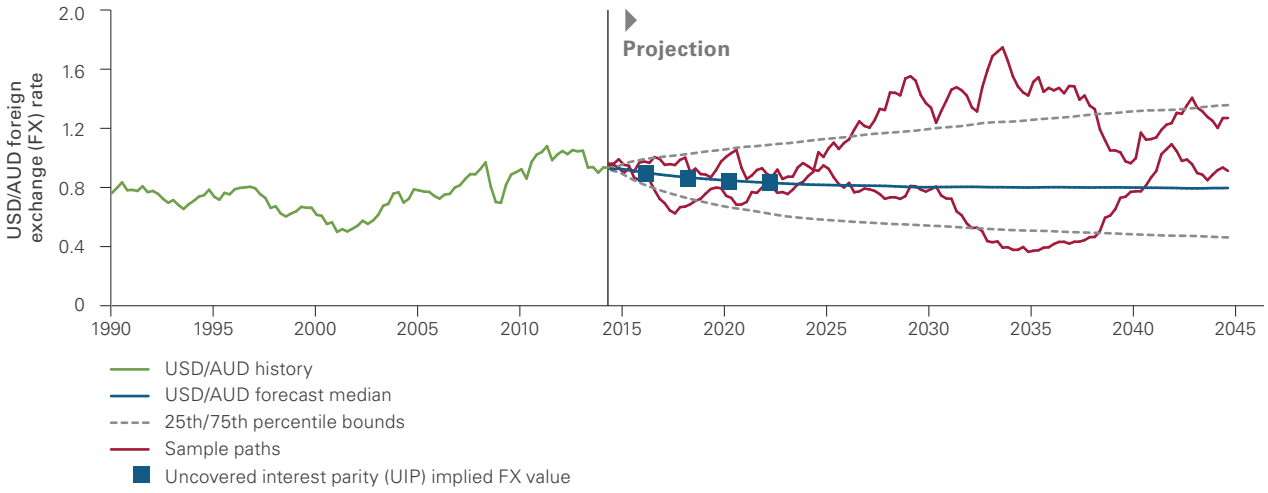
Developing portfolio solutions and other uses of VCMM

The VCMM's output, comprising distributions of asset returns, volatilities and correlations, has a variety of portfolio modeling and research uses for both personal and institutional investors. The model can perform analysis across a range of regional markets, including Australia, the US, UK and Europe.

Its applications include:

- long-term return expectations for Vanguard's Economic and Market Outlook

Figure 2 A currency forecast example, constructed from implied forward rates



Notes: Forecast corresponds to distribution of 10,000 simulations from VCMM. USD per AUD Q1 1990–Q1 2014 history from Moody's Analytics. VCMM forecast and calculated UIP implied foreign exchange values as of March 2014.

Sources: Vanguard and Moody's Analytics.

- Analysis of portfolio solutions such as life-cycle funds, managed funds and other diversified funds
- Scenario analysis and probability of meeting investment objectives for personal advice

It's important to point out that the model is not designed for short-term tactical asset allocation.

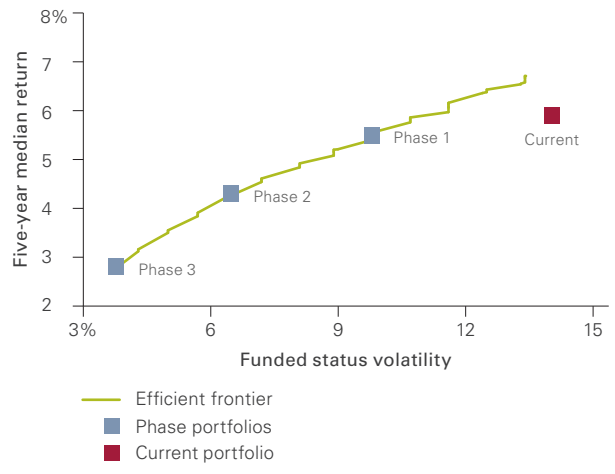
Figure 3 shows some example portfolio solutions using the VCMM. In each example, the VCMM output is used to solve a variety of portfolio problems, based on different investment objectives. These might include the probability of meeting these objectives, wealth accumulation projections, portfolio performance metrics, risk-return efficient frontiers and other non-traditional frontiers.

Figure 3a is an example of a non-traditional frontier based on liability-driven investment for pension clients in a defined benefit plan. **Figure 3c** shows how the analysis is used for life-cycle portfolios, which are primarily constructed to decrease risk over the working life of an investor in preparation for retirement.

Figure 3 Example of VCMM portfolio solutions

Defined benefit plans:

a. LDI efficient frontier



b. Terminal funding ratio

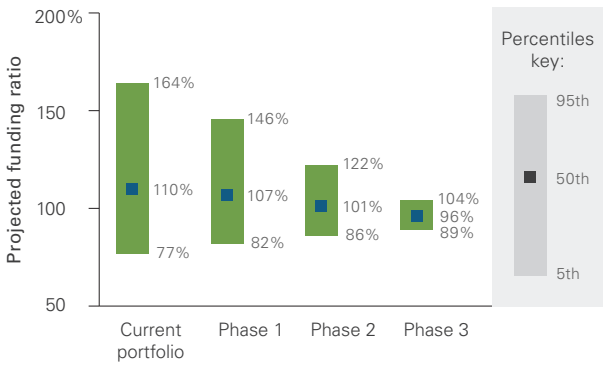
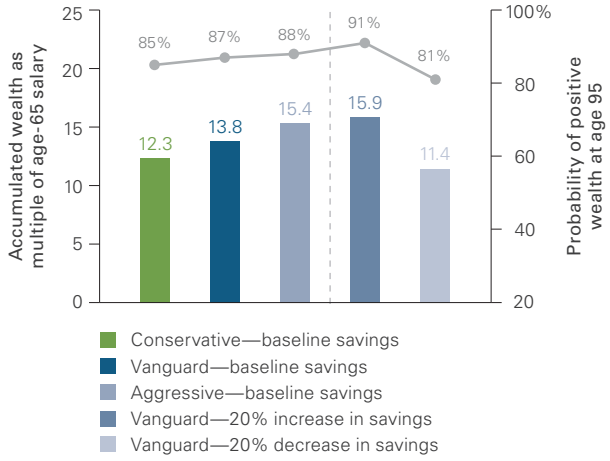


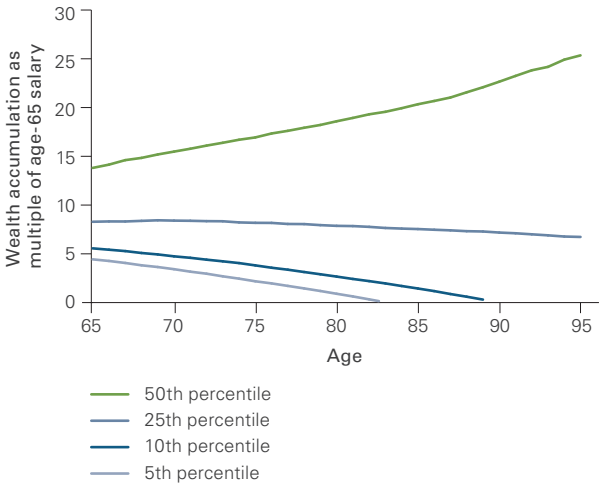
Figure 3 Example of VCMM portfolio solutions *(continued)*

Target retirement fund:

c. Impact of savings versus asset allocation

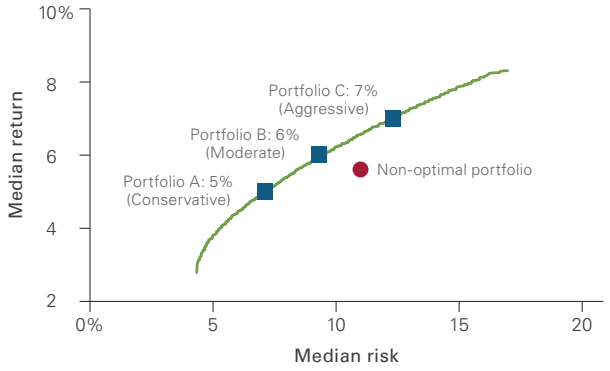


d. Drawdown scenarios—baseline replacement rate

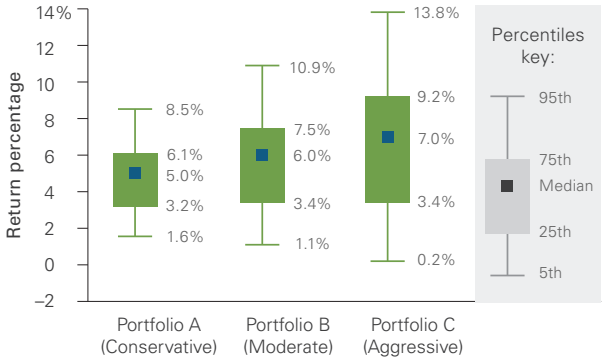


Asset allocation:

e. Efficient frontier for ten-year horizon



f. Range of returns



Notes: For figures (a) and (b), efficient frontier is based on forecasts corresponding to median values of 10,000 simulations. Distributions shown are based on 10,000 simulations. For figures (c) and (d), contribution rates represent those of "average" participant in Vanguard target retirement funds. "Aggressive," Vanguard, and "Conservative" glidepaths used average equity allocations of 70%, 60%, and 50%, respectively. For figures (e) and (f), efficient frontier is based on forecasts corresponding to median values of 10,000 simulations. In 11e, y-axis represents median nominal geometric returns, and x-axis is based on median standard deviation of annual returns, which is volatility. The optimization is based on annual rebalancing.

Source: Vanguard.

Figure 3e illustrates a traditional mean-variance frontier with three sample portfolios and **Figure 3f** shows the distribution of expected returns for each of these portfolios.

The portfolios on the efficient frontier with the maximum median return and minimum median volatility are the ones most likely to meet the client's investment objectives and risk tolerance. This portfolio optimisation analysis enables Vanguard to help clients narrow down the menu of possibilities to a few viable portfolios on the efficient frontier. The frontiers quantify the trade-offs between risk and return in the different portfolios.

VCMM limitations

While the VCMM is an advanced, quantitative simulation engine, like all models it does have its limitations. Some of these include:

- The accuracy of forecasts depends on the relevance of the historical sample in simulating future events.
- As the output alone can't always provide the most accurate answer, Vanguard overlays the quantitative analysis with additional qualitative analysis.

- The model assumes the relationship between variables is static, however, in reality correlations vary slowly with time. The VCMM mitigates this static assumption by using non-normal techniques in forecasting.

The data used in the VCMM is updated quarterly and re-estimated with historical observations. This continual update means current market conditions are always incorporated into the forecasts. Thus the simulation results can be heavily influenced by the last data point, particularly when looking at shorter time horizons.

In summary

- The VCMM is a proprietary model of global capital markets that helps clients make effective investment decisions.
- The model accounts for current market conditions in its forward return forecasts, as well as risk factors and premiums that can change over time.
- The model incorporates a qualitative overlay from experienced analysts in Vanguard's Investment Strategy Group.
- It integrates economic and financial variables that take into account many risk factors allowing investors to assess the impact of changes in interest rates, inflation and economic growth on their portfolios.