Validating Custom Risk-Neutral Asset Classes

Overview

In the GEMS® Economic Scenario Generator ("GEMS"), our native equity asset classes (SPX, MID, RTY and NDX) are calibrated to observed equity option prices. Many of our clients need to model additional equity indices such as EAFE and MSCI EM, for which we do not have option data. These indices are modeled as a GEMS return class with a beta to one of our native equity asset classes. This approach works well and produces asset class returns that pass the Martingale test. In a previous paper, we described this approach and the rules around creating custom risk-neutral assets; in this paper, we construct a custom risk-neutral asset class and validate the results against observed option prices.

GEMS Return Class

To test our return class approach, we focus on the Russell 2000 (RTY) index, where we have observed option prices. For this reason, we model RTY as a native equity index (Small Cap) in our standard risk-neutral template. However, for this test, we developed an alternative model based on its historical beta to the S&P 500. We then used the simulated returns to calculate a set of option prices and compared them to our observed prices.

To develop parameters for our alternative model, we performed regression analysis for historical price returns vs. the S&P 500. We examined 30 years of monthly data from 3/31/1995 – 3/31/2025.

- 360 monthly observations
- R2 = 0.685
- Beta = 1.095
- Intercept = -0.00104
- Correlation = 0.827
- Standard Error = 0.03270

GEMS Implementation

We used the above parameters to construct an aggregate return class in GEMS, which allows us to apply factors to previously defined return classes. Since we are using this in a risk-neutral context, we must follow the rules for creating custom risk-neutral asset classes, specifically:

- The model can only use returns, not economic variables (e.g., yields, GDP)
- The weights across asset classes must sum to 1
- The weights must be the same for price and income for every asset class
- Any residual must be independent and cannot adjust the mean return

Figure 1: GEMS Return Class Parameters

Return Class Weights	Income	Price
Large Cap	1.095	1.095
US Cash	-0.095	-0.095
Adjustments		
Mean	0.0	0.0
Standard Deviation	0.0	0.113276

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Consistent with our normal practice, we assigned a weight to the cash asset class such that the total weight sums to 1. In GEMS, the adjustments are annualized inputs, so we annualized the regression standard error by multiplying it by the square root of 12.

We used the above parameters to add a new return class to our standard 3/31/2025 risk-neutral template and ran a 1,000 scenario simulation, which we analyze in the following sections.

Martingale Results

First, we compared the Martingale test results for our native Small Cap asset class against our RTY return class. While RTY passes the Martingale test, the test results appear very different. This is not unexpected given the different modeling approach.

Figure 2: Martingale Test Results for Native Small Cap

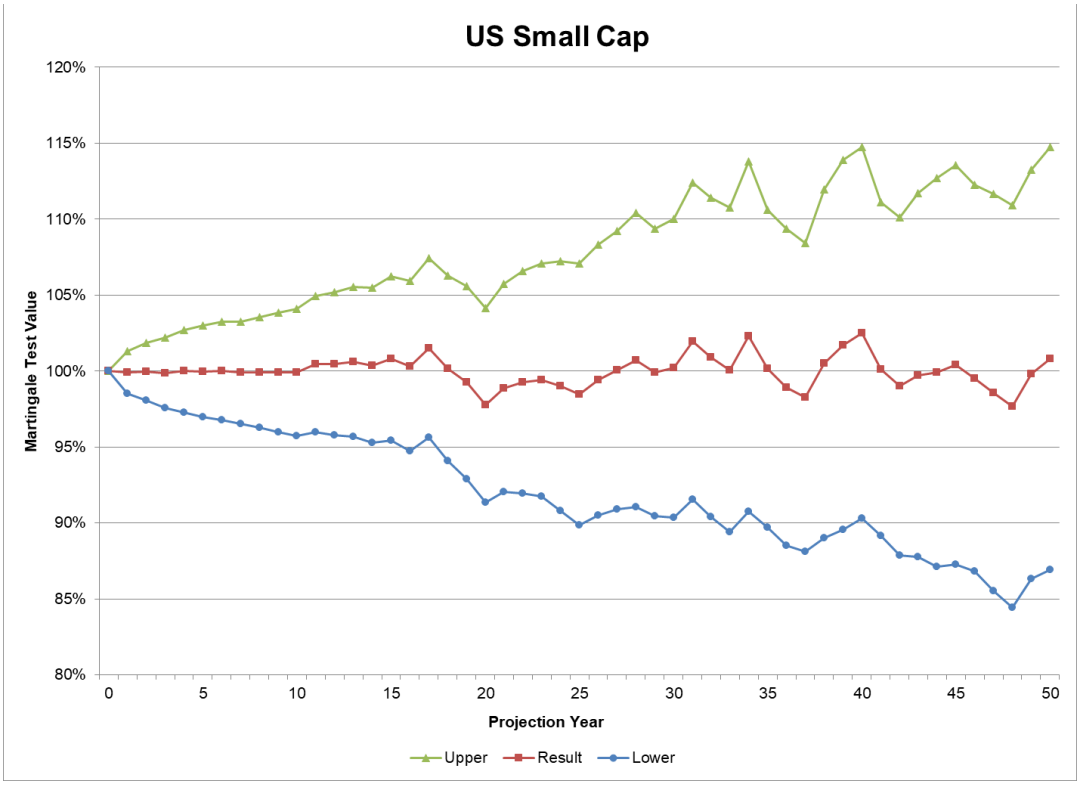

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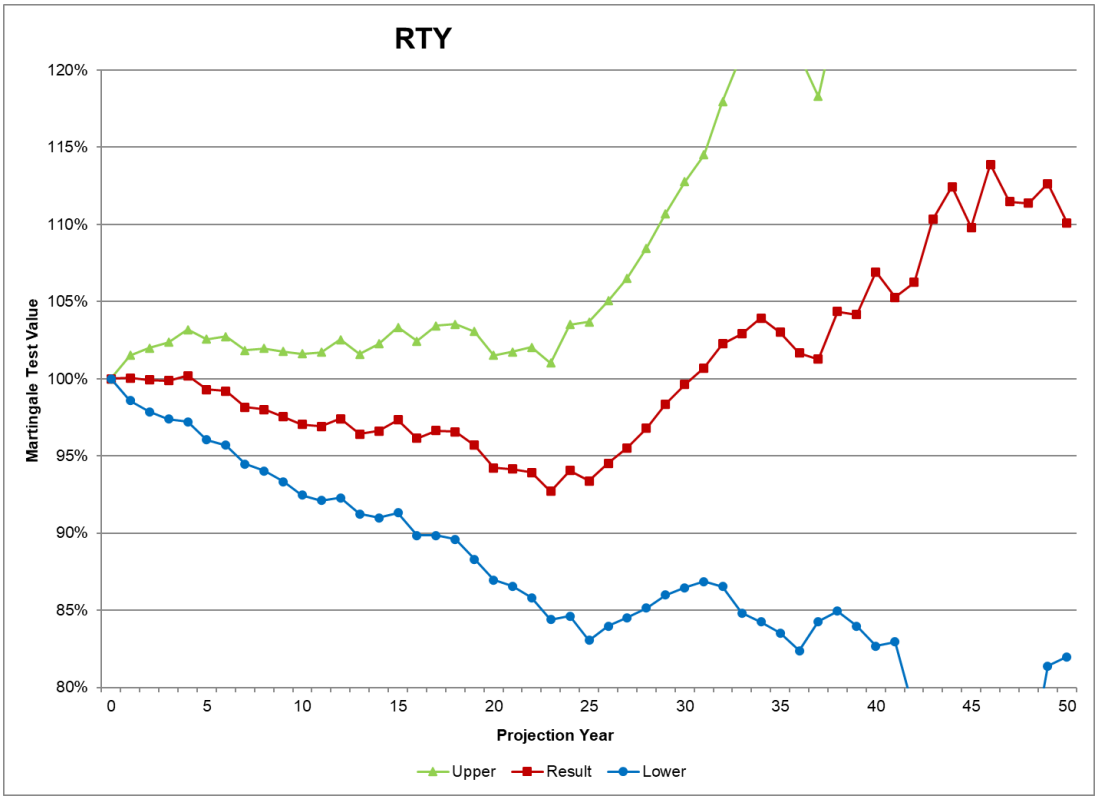
Figure 3: Martingale Test Results for RTY return class



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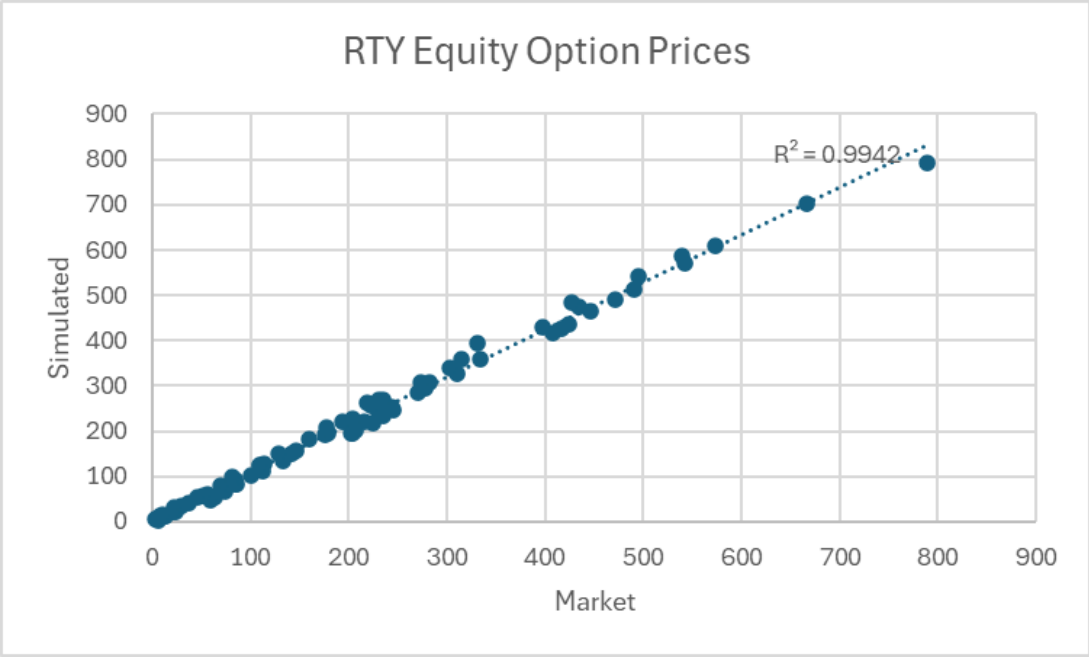
Option Pricing Test

The option pricing test compares the modeled option prices against the observed prices. To calculate the modeled option prices, we ran a simulation with 1,000 scenarios. Using the simulated results, we calculated put and call option prices for 38 calls and 38 puts for a total of 76 prices. The calculated prices align with the same moneyness and maturities used to calibrate the native small cap asset class.

Figure 4: Option Pricing Test Results



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The results are considered to be a good fit if the r-squared value is 95% or greater. Since our test results indicate an r-squared value of over 99%, our simulated prices can be considered a very good fit to the market.

It should be noted that we are comparing simulated option prices based on 1,000 scenarios against observed prices. Our normal practice is to evaluate analytical option prices generated by the model, not simulated prices. Unlike analytical prices, simulated prices are subject to sampling error inherent in the 1,000 scenarios. Hence, it would be reasonable to expect that the fit would be even tighter if we had run a larger set of scenarios.

Summary

Our analysis indicates that using a properly calibrated return class results in returns that pass the Martingale test and option prices that are a good fit to market prices. Based on this, we conclude that the return class presents a viable modeling approach for asset classes for which we do not have option prices.

Disclosures/Confidentiality Notice