Market Insight

Introducing Macroeconomic-Based Stress Testing

A Scenario for Rising Inflation and Interest Rates

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Abstract:

From quantitative easing to talk of tapering, a recurrent theme of 2013 among investors has been concern over rising interest rates. There are many ways to design a rising interest rate stress test, though basing this on history alone is a challenge. Historically, interest rates have risen for numerous reasons—central bank actions, inflation, flight to quality, and so on. The commonality between past regimes of rising interest rates is not obvious. In order to simplify and use a direct link to a particular macro effect, we consider this problem through the lens of the MSCI Macroeconomic model.

Why This Matters:

- The MSCI Macroeconomic model provides a framework to design stress tests based on specific macroeconomic scenarios.
- One way to construct a rising rates stress test is to specify an inflation shock within the macroeconomic model.
- The changing correlations between bonds and equities can have substantial impacts on the results of these stress tests.

Introduction

From quantitative easing to talk of tapering, a recurrent theme of 2013 among investors has been concern over rising interest rates. There are many ways to design a rising interest rate stress test, though basing this on history alone is a challenge. Historically, interest rates have risen for numerous reasons—central bank actions, inflation, flight to quality, and so on. The commonality between past regimes of rising interest rates is not obvious. In order to simplify and use a direct link to a particular macro effect, we consider this problem through the lens of the MSCI Macroeconomic model.

The MSCI Macroeconomic model provides a framework to generate adverse, but plausible, scenarios for macro shocks and the subsequent response of major equity and bond indices. We focus on one of these macro factors – inflation – to construct a stress test where rising rates are due to rising inflation. The shock to inflation translates (through the MSCI Macro Pricing model) into a shock to bond yields and equity indices.

The last step is to propagate these broad index shocks to our test portfolios using a market risk model. The market risk model estimates shocks to the overall portfolio based on correlations from a specified historical period. For our example, we consider a selection of fixed income and equity indices. The results for the fixed income portfolios are in line with expected output from the MSCI Macro Pricing model, but with some sensitivity to the analysis time period. The results for the equity portfolios are much more sensitive to the time period. This is due to the variation in bond-to-equity correlations across time. This suggests that rather than attempting to characterize the stress period based on the bond-equity correlation, risk managers should base their stress tests on the shocks derived from the Macro model for a set of relevant equity factors.

Macro Shocks and Their Impact on Bonds and Equity

Since 2012, MSCI has pursued a macroeconomic research agenda, which has been presented in a series of papers. The research has led to two model components: the MSCI Macroeconomic model, which produces projections for macroeconomic variables at various time horizons, and the MSCI Asset Pricing model, which relates the macroeconomic variables to asset prices. The two components may be used together to design stress tests.

The MSCI Macroeconomic model[1] uses a Bayesian Vector Autoregression (BVAR) fit to inputs such as real GDP growth and corporate profitability, which are observed quarterly and typically with a lag, and other variables such as inflation, which are observed more frequently.[2] The output of the model is a projected distribution of the various macroeconomic factors. The baseline scenario is defined as the median of this distribution and this scenario sets the bands against which stress scenarios can be measured. In Table 1 we see the baseline and confidence bands of projected inflation five years into the future.

We define macro risk as the potential for a persistent shock to trend growth or inflation. Referring to the confidence bands, we consider shocks that produce long-term inflation scenarios consistent with the higher percentiles in Table 1. Figure 1 shows a path of inflation for these scenarios: a shock to inflation at time zero which persists, resulting in an increase in year-ahead inflation of 1 percent or 3 percent relative to the baseline in five years' time.

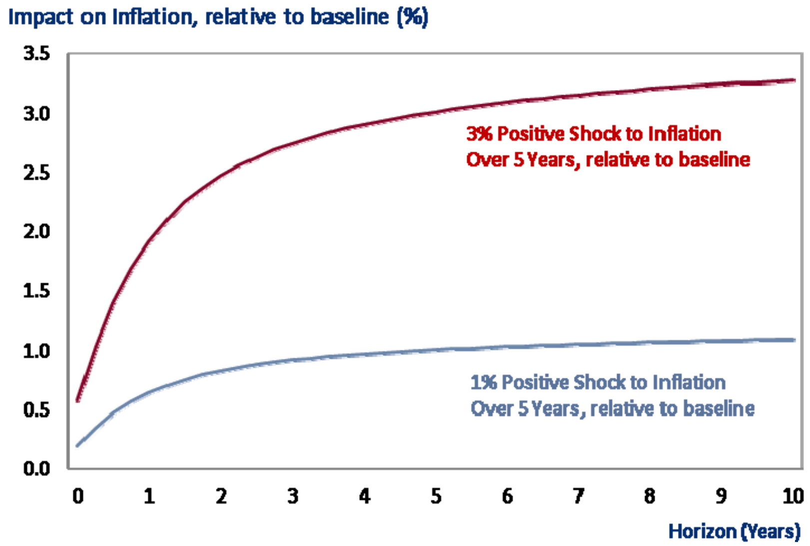
[1] Winkelmann, K, et al, 2013, "Macro-Sensitive Portfolio Strategies: Macroeconomic Risk and Asset Cash-Flows", MSCI Market Insight, March 2013.

[2] For more information about VAR models and the variables included see "Market Insight: Deconstructing Risk Parity Portfolios June 2013."

Table 1: MSCI Macroeconomic model's baseline estimate as of June 30, 2013, and five-years out confidence bands for the Consumer Price Index year-ahead inflation.

	Baseline	Confidence Bands 5 Years Out			
		5th Percentile	30th Percentile	70th Percentile	95th Percentile
CPI Inflation (Year-Ahead, %)	1.8	-1.8	0.8	2.8	4.8

Figure 1: Impact of positive shocks to inflation relative to baseline.



The first paper of the Macroeconomic series[3] argues that to understand the impact of macroeconomic stocks on asset prices, we need to go back to first principles: the value of an asset is the expected discounted value of current and future asset cash flows. In this framework, macro risk impacts valuation and risk via two channels: asset cash flows and discount factors. In the MSCI Asset Pricing model, both the cash flows and discount factors are related to macroeconomic variables. Therefore stress tests can be designed as the impact of a macro shock on portfolio value (and return). This is assessed by combining responses for asset cash flows with responses for discount functions.

Impacts on Bonds

The shocks to the macroeconomic variables are fed into the MSCI Asset Pricing model, resulting in impacts on bonds. The resulting shocks to bond yields are shown in Table 2, where we see that a positive shock to inflation produces a rise in bond yields. This is the basis of our rising rates stress test.

[3] Winkelmann, K, et al, 2012, "Macro-Sensitive Portfolio Strategies: How We Define Macroeconomic Risk", MSCI Market Insight, November 2012.

Table 2: Macro model impacts to bonds resulting from inflation shock.

Scenario	1% Increase in Inflation over 5 Years		3% Increase in Inflation over 5 Years	
Horizon	1st Quarter	1st Year	1st Quarter	1st Year
2-Year Bond Yield (%)	0.25	0.75	0.75	2.25
5-Year Bond Yield (%)	0.13	0.36	0.40	1.12
10-Year Bond Yield (%)	0.07	0.21	0.21	0.63

In order to provide some context of the magnitudes of these shocks (and assess the size of shock we wish to examine), in Table 3 we show the change in yields that have occurred over historical periods of rising interest rates.

Table 3: Historical changes in yields in periods of rising interest rates.

		US Government Debt Benchmark - Zero Coupon 24M			US Government Debt Benchmark - Zero Coupon 60M			US Government Debt Benchmark - Zero Coupon 120M		
Date start	Date End	start	end	change	start	end	change	start	end	change
15/10/1993	07/11/1994	3.81	7.06	**3.25**	4.57	7.73	**3.16**	5.19	8.05	**2.86**
29/12/1995	08/07/1996	5.18	6.43	**1.25**	5.38	6.81	**1.43**	5.58	7.05	**1.47**
05/10/1998	18/01/2000	5.39	6.47	**1.08**	5.43	6.64	**1.21**	5.45	6.76	**1.31**
13/06/2003	13/05/2004	1.09	1.46	**0.36**	2.09	2.58	**0.49**	3.25	3.74	**0.48**
18/12/2008	06/04/2010	0.71	1.15	**0.45**	1.30	2.76	**1.46**	2.17	4.15	**1.98**
01/05/2013	26/06/2013	0.21	0.39	**0.18**	0.68	1.45	**0.77**	1.78	2.62	**0.85**

Comparing Tables 2 and 3, the magnitude of the historical changes in yields (which have occurred in periods of approximately one year) are most in line with the changes in the rightmost column of Table 2, that is the changes over the first year in the scenario corresponding to a 3 percent increase in inflation over five years. This supports using the 3 percent inflation shock (95th percentile from Table 1) in order to define our stress scenario.

We note that the BVAR model produces changes in yields which affect the short end of the curve more than the long end. Though not typical in the historical periods we considered, this type of shift has previously occurred, in particular between 1993 and 1994. Overall, given that the 3 percent inflation shock is of a high percentile and the resultant changes in yields from the MSCI Asset Pricing model are in line with those which have been observed historically (in times of rising yields), we take this as a reasonable basis to define a rising rates stress test.

Impacts to Equities

In the "Macroeconomic Risk and Asset Cash-Flows" paper,[4] we see that equities are substantially impacted by shocks to GDP growth. Through the BVAR model, the two previously applied inflation shocks impact GDP growth. Applying these moves through the MSCI Asset Pricing model produces the impacts to equity markets. These relative shocks are presented in Table 4. We note that equity markets

[4] Winkelmann, K, et al, 2013, "Macro-Sensitive Portfolio Strategies: Macroeconomic Risk and Asset Cash-Flows", MSCI Market Insight, March 2013.

are much less affected by a pure inflation shock than the bond markets. We also note that the impact on growth and value stocks are different, reflecting the macro impacts to their cash-flows.

Table 4: Macro model impacts to equities resulting from inflation shock.

Scenario	1% Increase in Inflation over 5 Years		3% Increase in Inflation over 5 Years	
Horizon	1st Quarter	1st Year	1st Quarter	1st Year
Equity Market (%)	0.01	0.10	0.04	0.30
Large Cap (%)	-0.08	-0.14	-0.25	-0.43
Small Cap (%)	0.52	1.09	1.57	3.26
Value (%)	0.37	0.83	1.12	2.50
Growth (%)	-0.39	-0.64	-0.67	-1.91

Propagating Inflation Shock through the Market Risk model

In order to propagate the shocks to the broad market indices to other portfolios, we use a market risk model. We construct a "Rising Inflation Leading to Rising Yields" predictive stress test in RiskManager using the shocks in the right-most column of Table 4, which are the shocks over the first year in a scenario leading to a 3 percent inflation shock.

We define the predictive stress test by specifying shocks on the following predictive risk factors:

- S&P 500 Index rises 0.3 percent
- USD Govt 24M increases by 2.25 percent
- USD Govt 60M increases by 1.12 percent
- USD Govt 120M increases by 0.63 percent

The shocks to equities are relative shocks, whereas the shocks to the yield curve are absolute.

The predictive stress test methodology uses the historical correlations between the risk factors in the portfolio and the predictive risk factors. The historical correlations define the relationship between the portfolio risk factors and the predictive risk factors in order to propagate the shocks through to the portfolio.

An important consideration is the dependence of the relevant historical correlations on the time period chosen. We investigate the differences in results to our example portfolios by varying the lookback period (i.e., risk setting).

The risk settings we use are as follows:

- One year historical daily returns (1y hist)
- Three years historical daily returns (3y hist)
- Five years historical daily returns (5y hist)
- Daily returns from period of rising rates in 2003-2004 (2003y)
- Three years of weekly returns (3y5D)
- Five years of weekly returns (5y5D)

Fixed Income Portfolio Results

After defining the stress test as above, we first apply it to several fixed income indices. The date of the analysis is June 17, 2013, just before the U.S. Federal Reserve Board made its announcement that there may be a tapering of the QE program (the reaction in the markets after the announcement would potentially change the correlation structure).

We present the results in Table 5. The JP Morgan United States Government Bond Index is less sensitive to the time period, and shows a consistent 5 to 6 percent loss across the different risk settings. The results for the BoA Merrill Lynch 10+ Year US Treasury Index are more varied across risk settings. This index has duration of approximately 15 years, and so is dependent on the 30Y node of the yield curve. Since our stress test only specifies shocks to the 2, 5 and 10Y nodes, the shock to the 30Y node is sensitive to correlations, explaining the variation in this index's results.

Table 5: Predictive Stress Test Results for Fixed Income Index Portfolios.

	Delta PV (year shock)					
	1 yr hist	3 yr hist	5yr hist	rr2003	3yr5D	5yr5D
BofA Merrill Lynch 5-10 Year US Treasury Index	-10.0%	-6.8%	-5.0%	-5.5%	-5.8%	-3.4%
BofA Merrill Lynch 10+ Year US Treasury Index	-6.4%	-10.2%	-6.5%	-7.6%	-13.4%	-9.4%
Citi US Broad Investment Grade Corporate Index	-6.2%	-5.4%	-4.6%	-4.4%	-5.6%	-3.7%
JP Morgan United States Government Bond Index	-5.8%	-5.8%	-4.5%	-4.9%	-6.4%	-4.5%

Equity Portfolio Results

We apply the predictive stress test to some equity portfolios, again with analysis date of June 17, 2013. The results are presented in Table 6 below.

Table 6: Predictive Stress Test Results for Equity Index Portfolios.

	Delta PV (year shock)					
	1 yr hist	3 yr hist	5yr hist	rr2003	3yr5D	5yr5D
Russell 1000 Growth Index	-1.2%	0.8%	-2.3%	0.0%	2.0%	0.5%
Russell 1000 Value Index	9.5%	-1.3%	-0.1%	-0.8%	0.0%	1.3%
Russell 2000 Value Index	17.7%	-1.0%	-7.0%	-2.0%	6.9%	0.6%
Russell 2000 Growth Index	12.1%	-1.1%	-8.0%	-1.5%	6.7%	0.6%
S&P 500 Index	4.2%	0.2%	-0.4%	-0.3%	1.0%	2.0%

The results for the equity portfolios are highly sensitive to the time period chosen. In particular, the results for the Russell 2000 Value Index range from negative 7 percent to nearly positive 18 percent. These ranges are large compared with the results for the fixed income indices in Table 5.

In order to understand these results, and given that these portfolios have hundreds of risk factors and the stress test itself has four independent risk factors, we simplify the test. We set up two simpler stress tests, one with a shock to the S&P500 Index and another stress test with shocks to both the S&P500 Index and the 2Y rate (using the shock magnitudes from Table 4). The stress tests are applied to a few different equity indices and the results presented in Tables 7 and 8.

Table 7: Predictive Stress Test Results for Simple Stress Test (Equity only shock).

Equity Shock	Delta PV						
	Macro	1 yr hist	3 yr hist	5yr hist	rr2003	3yr5D	5yr5D
S&P 500 Index	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Russell 1000 Value Index	2.5%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Russell 1000 Growth Index	-1.9%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
MSCI USA Small Cap Index	3.3%	0.3%	0.4%	0.3%	0.2%	0.4%	0.4%

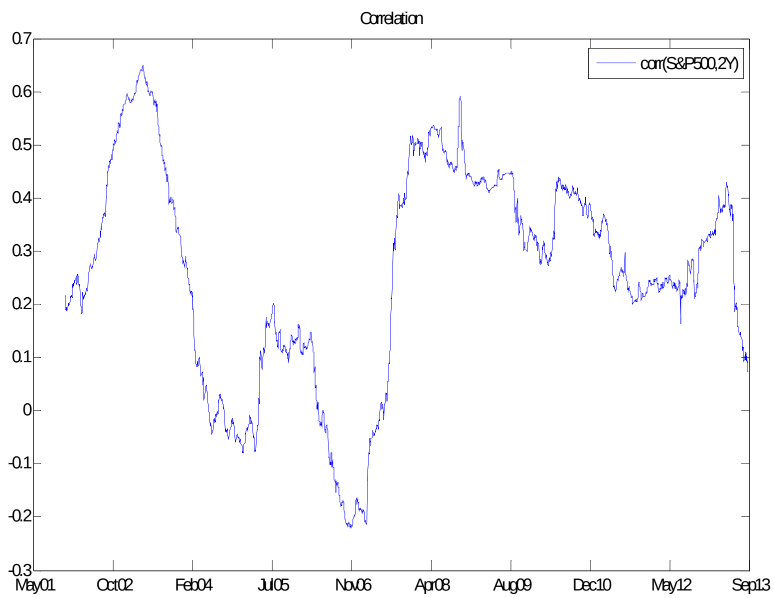
Table 8: Predictive Stress Test Results for Simple Stress Test (Equity and 2Y shock).

Equity and 2Y Shock	Delta PV						
	Macro	1 yr hist	3 yr hist	5yr hist	rr2003	3yr5D	5yr5D
S&P 500 Index	0.3%	2.9%	0.1%	-0.4%	0.0%	0.3%	0.1%
Russell 1000 Value Index	2.5%	7.4%	0.0%	0.0%	-0.7%	1.7%	-0.5%
Russell 1000 Growth Index	-1.9%	-2.0%	-0.9%	-1.6%	1.0%	-2.2%	0.3%
MSCI USA Small Cap Index	3.3%	8.0%	-2.8%	-3.6%	1.0%	-0.1%	0.4%

Note the large difference between the results in Table 7 and Table 8. By adding the rate shock, the stress test entirely changes and is unstable as regards time period (similar to the more complex stress test applied above). If the predictive stress test is defined just using the S&P500 Index shock then the results are consistent across time period. Additionally, neither of the simple stress tests mimics the results of the Macro model.

In Figure 2, we show the rolling one year daily correlations between the S&P 500 Index and the US 2Y Government rate. This provides some explanation for the instability in the equity stress test results.

Figure 2: Correlations between the S&P 500 Index and the US 2Y rate.



The correlation between bonds and equities is clearly time period dependent. It is not surprising that relying on this correlation to propagate shocks from interest rates to equities produces unstable results. Recall that the premise of this stress test is to examine the impact of a shock to inflation. In order to capture the behavior of equities as suggested by the MSCI Macroeconomic model, we should not rely on the historical bond-equity correlations from the risk model, but rather use the outputs of the Macroeconomic model directly. It is not necessary to specify the interest rate shock in the risk model, since the effect of rising rates is incorporated in the Macroeconomic model forecast of the equity shock.

For particular portfolios, we recommend that risk managers select the equity index most similar in style to the portfolio, and apply the equity index shock from the Macroeconomic model. In short, risk managers should use the Macroeconomic model to apply shocks directly to the most relevant factors, and rely on the risk model correlations only for more marginal factors.

Conclusion

Rather than constructing a historical stress test for rising interest rates, which is not a straightforward task, we utilize the infrastructure of our MSCI Macroeconomic model to construct a stress test of rising inflation that leads to rising interest rates. The model produces shocks to equity and bond indices that we propagate using a market model to other equities, rates, curves, and so forth. The application of this stress test through RiskManager shows that this approach works well for fixed income portfolios. Equities require a little more consideration due to the changing historical correlations between equities and rates. We conclude that it is best to choose predictive factors that best represent the portfolio, and specify the shocks to these factors directly from the Macro model.

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[1] *As of September 30, 2012, as published by eVestment, Lipper and Bloomberg on January 31, 2013* *Apr 2013*