cree: the CI Risk Engine

Interest Rate Shock Model and other shock models

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What is the *Interest Rate Shock Model*?

> *"All models are wrong but some are useful" — George Box (English statistician)*

Start with a multi factor model with only two factors, being the benchmark equity index (B) and the bond index (F for fixed income):

$$r_t = \alpha + \beta_B r_{B,t} + \beta_F r_{F,t} + \theta_t$$

For every stock, I run a **multilinear regression** using three years of weekly historic data to determine the values of α, β_B and β_F. The result is a simple linear model: plug in returns of the two factors to get an estimated return of the stock.

To build a complete *Interest Rate Shock Model*, we use simpler 1-factor models to estimate how yield changes affect the benchmark and bond returns, then plug those estimates into the above equation.

The factors and the shock parameter

For the benchmark, use the *MSCI AC World* total return index.

For the yield, use the *U.S. 10y Treasury Yield*. When I shock the yield (by increasing it by 100 bp), I actually compute the log return of the latest yield:

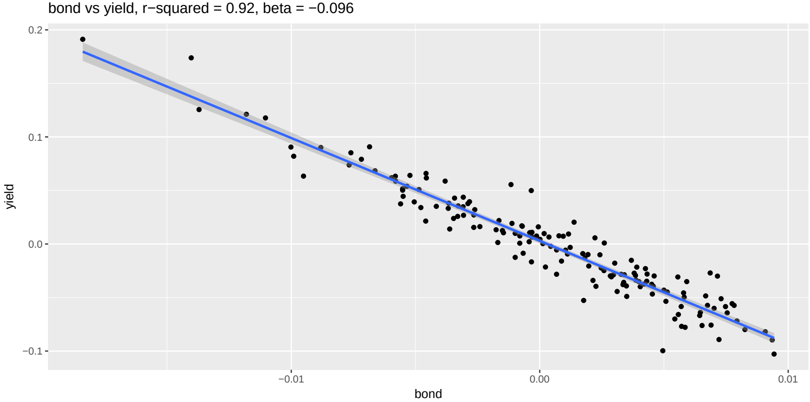
$$log(3.45\%) - log(2.45\%) = 0.3424$$

is the "return of the yield" shock. I use this to estimate the shocked returns of the benchmark and bond index.

For the bond, use *Citigroup US Broad Investment-Grade Treasury Bond Index*. It measures "the total rate of return performance for bond markets with a remaining maturity of at least one year" and is "composed of US Treasuries excluding Federal Reserve purchases, inflation-indexed securities and STRIPS" *(?)*. Northfield tends to use Citigroup fixed-income indices, and for this yield I find the correlation to be very good (see next page).

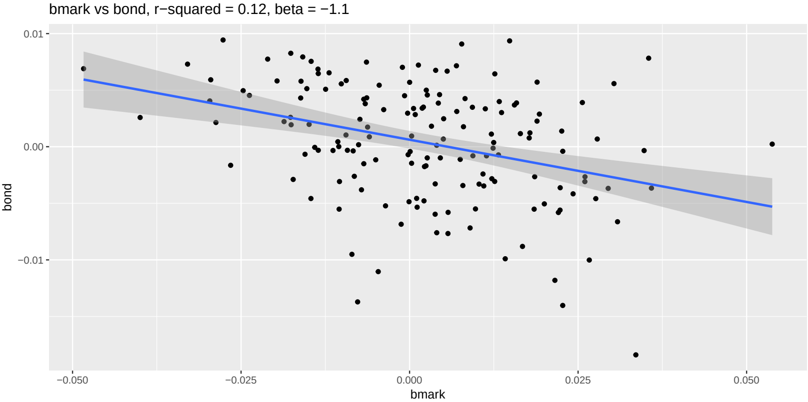
How yield affects bond index returns

Returns of the yield are highly correlated to bonds: saying "The (return of the) yield is $+x\%$" is almost the same as saying "The bond index goes down $-0.096x\%$":



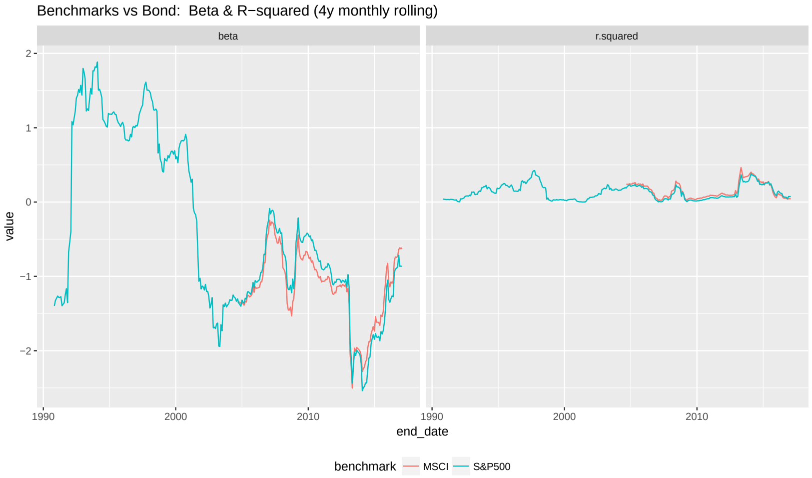
How yield affects benchmark returns

Don't forget correlation: If the bond changes, then the benchmark will change, too:



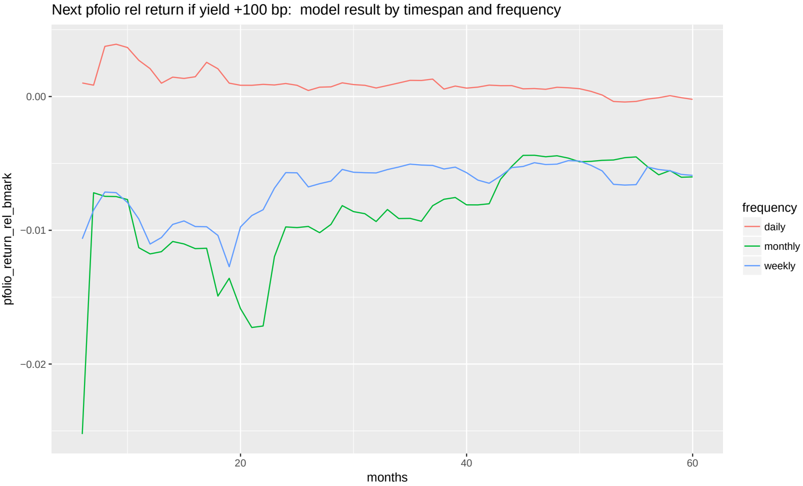
Equities vs fixed income throughout history

Disclaimer: benchmarks and bonds now have low correlation *(remember: correlation^2 = R^2)* and are inversely related ($\beta < 0$)



Why 3 years weekly?

We tried all timespans from six months to five years, with daily, weekly and monthly frequencies:



Now the results:

I compute this model for each stock in the global portfolios (GLUF and Global Pensions). Then I shock the 10Y U.S. Treasury Yield by $+100$ bps and calculate the estimated return of your portfolio based on latest weights in the database. I find:

- PCGLUF estimated return $=$ 3.07%.
- benchmark estimated return $=$ 3.69%.
- Therefore, we estimate PCGLUF would underperform by -0.62% in this scenario.

Similarly, PCGPEN estimated return is 2.08%, or -1.61% relative the MSCI AC World Total Return Index.

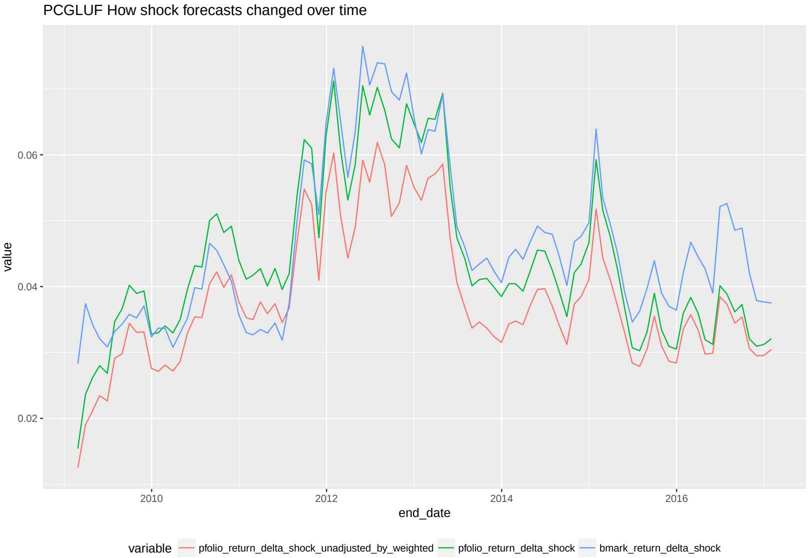
Checks and biases as of 19 Feb 2017

> *"The fools are certain and the intelligent full of doubt." — Bertrand Russell*

I also computed the model for *every stock in the MSCI AC World*:

- **Internal consistency:** Benchmark estimated shocked return is 3.80% when computed in this way. Compare this with 3.75% shocked return I got from our simpler linear model.
- **Currency bias:** When I restrict my by-stock calculations to US stocks, my total shocked return of the MSCI US stocks is 4.5%.
- **Industry groups:** Banks (+11.4%), Diversified Financials (+9.1%), Energy (+7.1%), Insurance (+6.7%), Automobiles (+6.5%) and Semiconductors (+6.4%) are the MSCI industry groups with the highest shocked returns. Lowest are Utilities (-4.0%), Real Estate (-2.5%), Food/Beverage/Tobacco (-0.4%) and Household/Personal Products (+0.5%)

How the results changed through history



Other shock models

Similar to the *Interest Rate Factor Model*, I wrote other 2-factor models of the form

$$r_t = \alpha + \beta_B r_{B,t} + \beta_F r_{F,t} + \theta_t$$

where B is the benchmark equity index and the F is another factor. I've tried changes in *Brent Oil*, various currencies and a USD currency basket index (ticker *DXY-IFUS* in FactSet).

Results are on the next page, but are better viewed in Excel

Other shock models' results

Table 1: Table continues below

Portfolio	AUD USD +10%	AUD USD -10%	AUD EUR +20%	AUD EUR -20%	Crude +50%	Crude -50%
Portfolio	-4.65%	4.65%	-2.14%	2.14%	1.89%	-1.89%
Benchmark	-4.10%	4.10%	-0.64%	0.64%	3.77%	-3.77%
rel	-0.55%	0.55%	-1.50%	1.50%	-1.88%	1.88%

(there is a nicer version of this in Excel)

How does this compare to Barra?

Shocked returns according to *Barra*'s risk model, using data from Oct 2013 to Oct 2016:

Portfolio	AUD USD up 10%	AUD USD down 10%	AUDEUR up 20%	AUDEUR down 20%	Crude Oil up 50%	Crude Oil down 50%	US Treasury up 100bps	US Treasury down 100bps	US Treasury up 25bps	US Treasury down 25bps
CI Global Portfolio	-3.4%	3.4%	-4.5%	4.5%	1.5%	-1.5%	6.4%	-6.4%	1.6%	-1.6%
Benchmark	-1.8%	1.8%	-1.6%	1.6%	2.8%	-2.8%	8.0%	-8.0%	2.0%	-2.0%
PORTFOLIO RELATIVE BENCHMARK	**(1.7%)**	**1.7%**	**(3.0%)**	**3.0%**	**(1.4%)**	**1.4%**	**(1.5%)**	**1.5%**	**(0.4%)**	**0.4%**

Shocked returns according to *cree*, the CI Risk Engine (using data from Oct 2013 to Oct 2016):

Portfolio	AUD USD up 10%	AUD USD down 10%	AUDEUR up 20%	AUDEUR down 20%	Crude Oil up 50%	Crude Oil down 50%	US Treasury up 100bps	US Treasury down 100bps	US Treasury up 25bps	US Treasury down 25bps
CI Global Portfolio *(which is 9% cash as*	-4.6%	4.6%	-2.8%	2.8%	2.0%	-2.0%	3.1%	-5.6%	0.9%	-1.0%
Benchmark (MSCI AC World in AUD)	-3.9%	3.9%	-1.2%	1.2%	4.1%	-4.1%	4.2%	-7.6%	1.2%	-1.4%
PORTFOLIO RELATIVE BENCHMARK	**(0.6%)**	**0.6%**	**(1.5%)**	**1.5%**	**(2.1%)**	**2.1%**	**(1.1%)**	**2.1%**	**(0.3%)**	**0.4%**

Figure 1: I also computed the model over the same timeframe which Barra did for us a couple of months ago (October 2013 to October 2016)

Why so different from other risk models?

The two main differences with a true risk model (by Northfield, Barra or UBS) are:

1. Most risk models use "exponentially decay weighted" observations. This means history has a half-life, and the model puts more emphasis on recent data than older data.
2. Other risk models have more factors, including:
   - Sectors (GICS or otherwise)
   - Regions or countries
   - Currencies
   - Oil prices
   - The usual quant signals (size, Value/Growth, etc)
   - Some economic signals (IP, Slope of the Term Structure, etc)