

# Interest Rate Shock Model

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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  $\alpha$ ,  $\beta_B$  and  $\beta_F$ . 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:

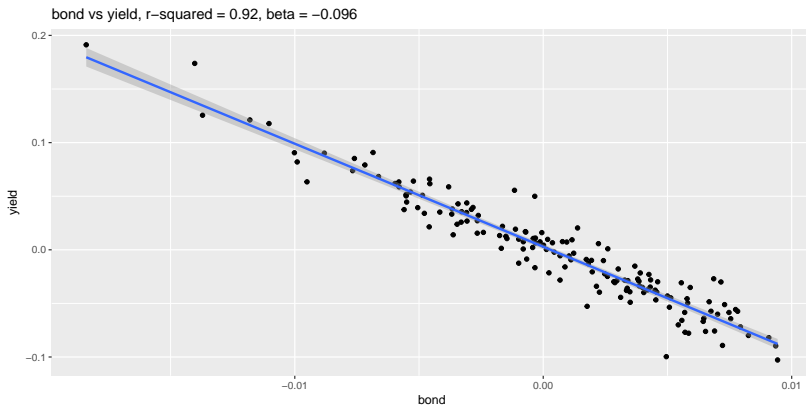
$$\log(3.45\%) - \log(2.45\%) = 0.3424$$

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

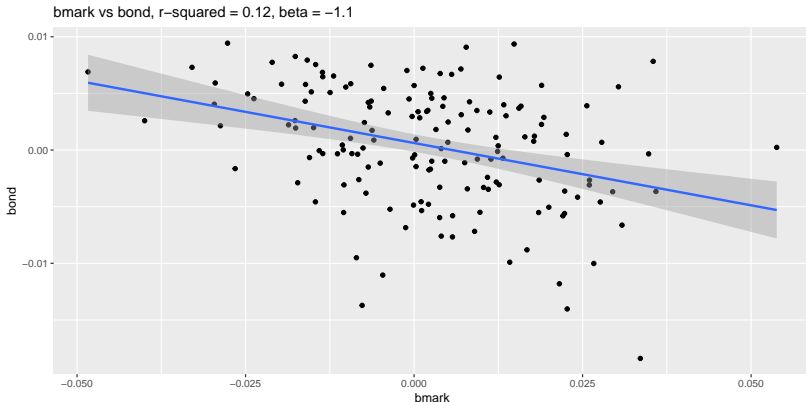
*Returns of the yield* are highly correlated to bonds: saying “The (return of the) yield is  $+x\%$ ” is almost the same as saying “The bond index goes down  $-0.096x\%$ ”:



# How yield affects benchmark returns

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

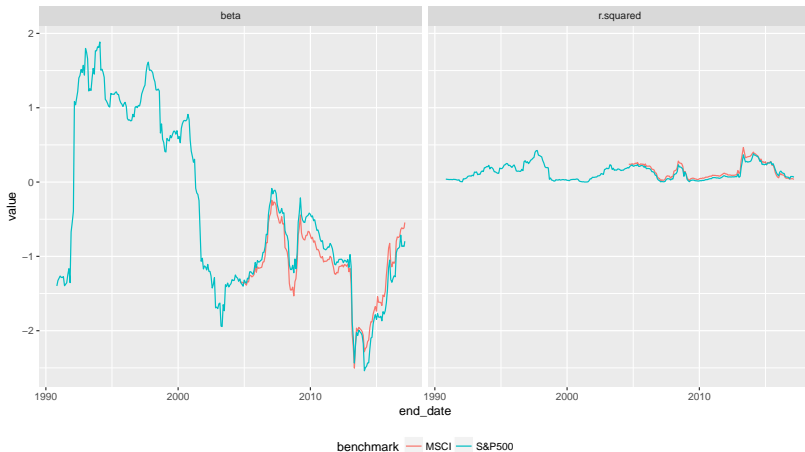
*Don't forget correlation:* If the bond changes, then the benchmark will change, too:



# Equities vs fixed income throughout history

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

Benchmarks vs Bond: Beta & R-squared (4y monthly rolling)



# 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 = 3.06%.
- ▶ 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.



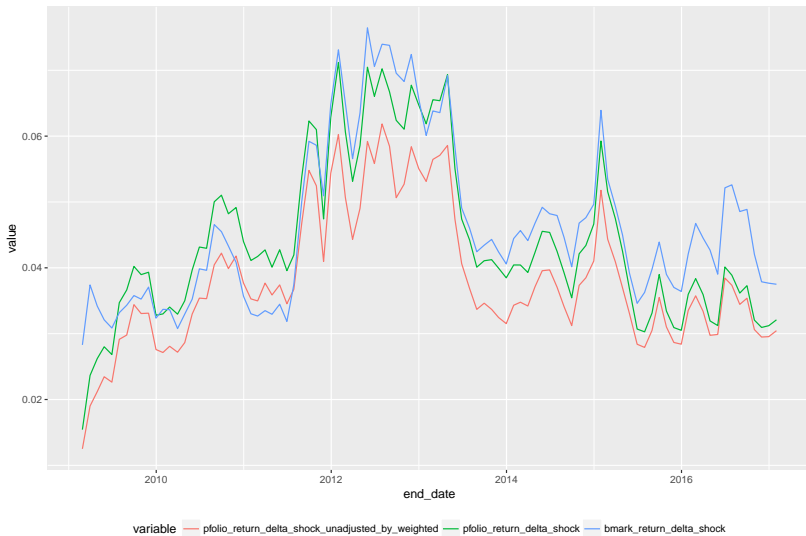
## Checks and biases as of 19 Feb 2017

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

PCGLUF How shock forecasts changed over time



# 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%
<b>PORTFOLIO RELATIVE BENCHMARK</b>	<b>(1.7%)</b>	<b>1.7%</b>	<b>(3.0%)</b>	<b>3.0%</b>	<b>(1.4%)</b>	<b>1.4%</b>	<b>(1.5%)</b>	<b>1.5%</b>	<b>(0.4%)</b>	<b>0.4%</b>

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%
<b>PORTFOLIO RELATIVE BENCHMARK</b>	<b>(0.6%)</b>	<b>0.6%</b>	<b>(1.5%)</b>	<b>1.5%</b>	<b>(2.1%)</b>	<b>2.1%</b>	<b>(1.1%)</b>	<b>2.1%</b>	<b>(0.3%)</b>	<b>0.4%</b>

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)

## Other shocks

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 the all US Dollar basket index (ticker *DXY-IFUS* in FactSet).

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

## Other shocks' results

Table 1: Table continues below

	AUD USD	AUD USD	AUD EUR	AUD EUR
Portfolio	+10%	-10%	+20%	-20%
Portfolio	-4.67%	4.67%	-2.16%	2.16%
Benchmark	-4.10%	4.10%	-0.64%	0.64%
rel	-0.57%	0.57%	-1.52%	1.52%

Crude	Crude
+50%	-50%
1.88%	-1.88%
3.77%	-3.77%
-1.89%	1.89%

(there is a nicer version of this in Excel)