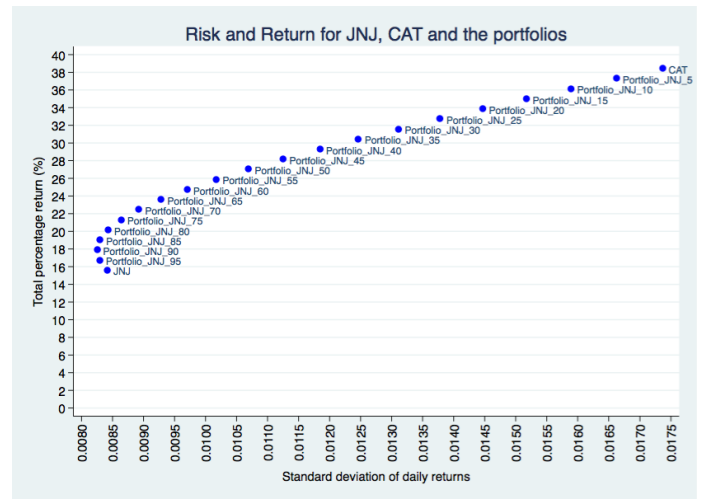
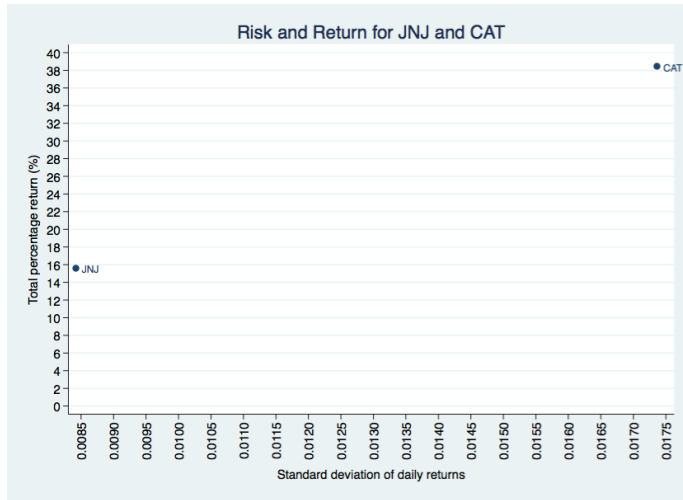


Portfolio

JNJ and CAT are at two distinct securities. While JNJ has lower risk and lower return, CAT has higher risk and higher return.



We combine risky CAT (5%) and low risk JNJ (95%) and we get a portfolio that has lower risk than even the JNJ... Is there an error? How is this possible?

Diversification effect

Let's check our numbers, just to make sure, using the traditional portfolio standard deviation equation. Standard deviations:

stats	ln_JNJ	ln_CAT	ln_Por~o
sd	.0084288	.017411	.0083047

Variance-Covariance matrix:

	ln_JNJ	ln_CAT
ln_JNJ	.000071	
ln_CAT	.000043	.000303

$$\sigma_{i,P} = \sqrt{w_1^2 \sigma_1^2 + w_2^2 \sigma_2^2 + 2w_1 w_2 Cov_{1,2}} \tag{1}$$

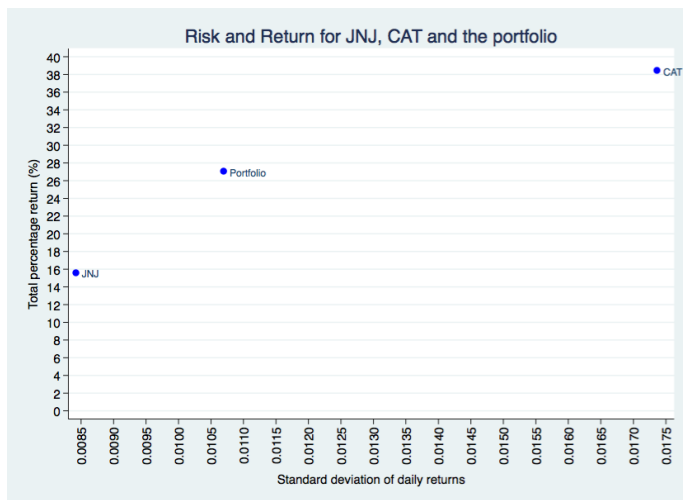
$$\sigma_{i,P} = \sqrt{(0.95^2 \times 0.0084288^2) + (0.05^2 \times 0.017411^2) + (2 \times 0.95 \times 0.05 \times 0.000043)} \tag{2}$$

$$\sigma_{i,P} = 0.0083047 \tag{3}$$

Diversification effect...

Equal weight

Let's create an equally weighted portfolio using these two stocks JNJ and CAT. Since this is an equally weighted portfolio, 50% weight will be for JNJ and 50% weight will be for CAT. Since JNJ and CAT are two distinct stocks with respect to risk and returns, would this portfolio be best of both worlds?



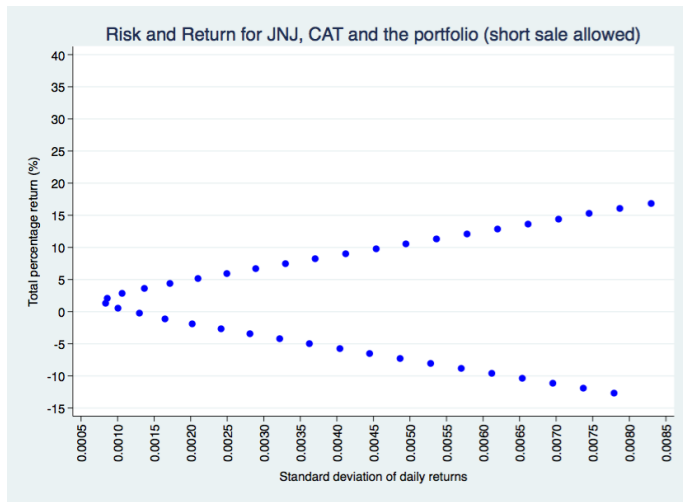
Different weights



Different weights

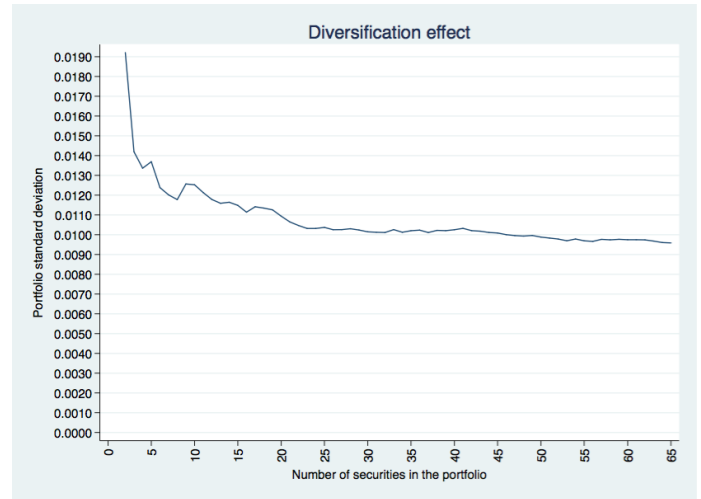
What happens if short sales are allowed? With no short sale allows, the weights can vary from 0% to +100%. However, with the short sale allowed, the weights vary from -100% to +100%.

Different portfolio weights for JNJ and CAT with short sale allowed.



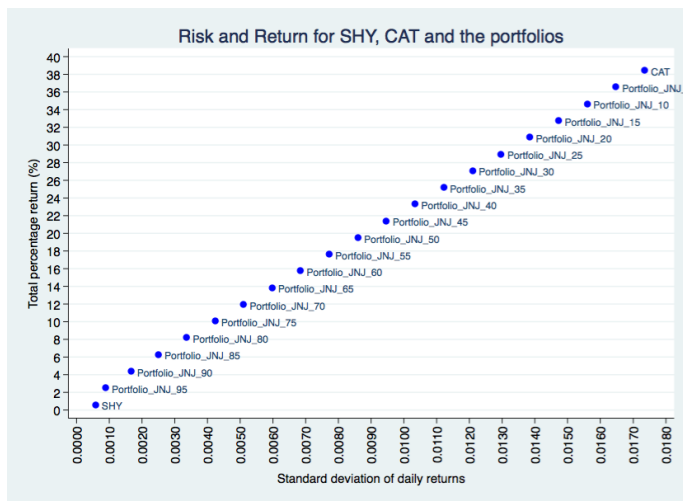
Diversification effect

In order to evaluate the diversification effect, we will look at Dow Jones Composite Average stocks (65 stocks). We evaluate the risk impact of an additional security in the portfolio.



Two securities with risk-free asset

Let's include the risk-free asset in the portfolio. We will use SHY as the proxy for the risk-free asset.

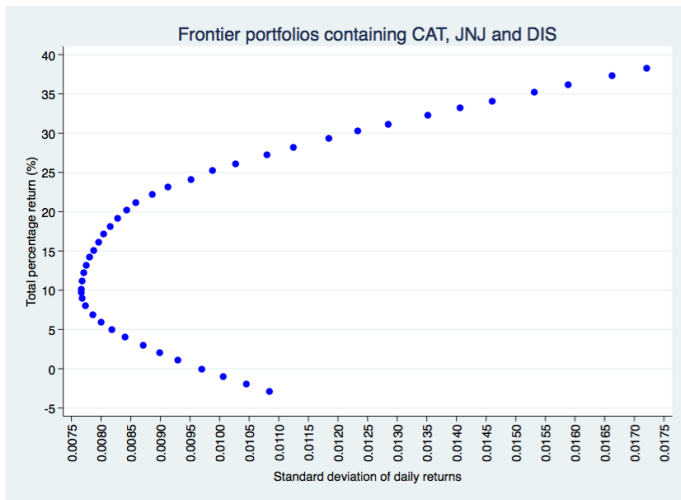


Notice the marginally decreasing effect of security additions. Each additional security will lower the **diversifiable risk**. In other words, we will diversify away idiosyncratic risk.

Notice the minimum standard deviation (.0095865) even after 65 securities are included. **Market Risk:** The minimum standard deviation (.0095865) that cannot be diversified away. This is defined as the **non-diversifiable risk**.

Portfolio that minimizes risk

In order to evaluate the portfolio that minimizes risk, we will look at Dow Jones Industrial stocks (30). **Minimum risk portfolio:** Weights for each stock in the portfolio are changed until the resulting portfolio has the lowest standard deviation. For each level of objective return, we generate a new *minimum risk portfolio*. Each of these portfolios (for each level of return) are referred to as a **Frontier Portfolio**. We will then plot these frontier portfolios on our Risk-Return chart.



Capital Market Line (CML)

For the capital market line (CML), we add a risk-free asset to the frontier portfolios.

