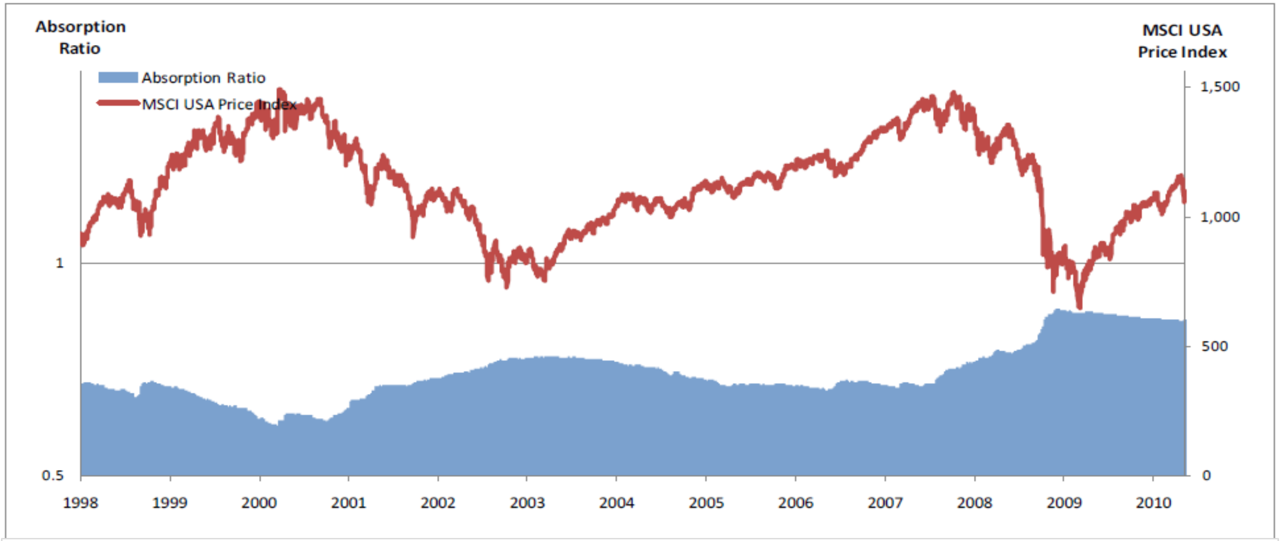
The Relationship between the US Economy's Information Processing and Absorption Ratio's

Edgar Parker, Jr.* (New York Life Insurance Company)

Absorption Ratio vs MSCI (Large Cap Equities) [1]



(Top) Used in accordance of permissions granted by © Mark Kritzman, Yuanzhen Li, Sebastien Page, and Roberto Rigobon 2010 on page 1 of[1]

Information Processing Ratio vs SP500 (Large Cap Equities) [2]

*(The views expressed in this paper represent the author's own and do not reflect those of NYLIC or NYLIM)

The Absorption Ratio

$$AR = \frac{\sum_{i=1}^{n} \sigma_{E_i}^2}{\sum_{j=1}^{N} \sigma_{A_j}^2}$$

Where,

AR = Absorption Ratio

N = number of assets

n = number of eigenvectors used

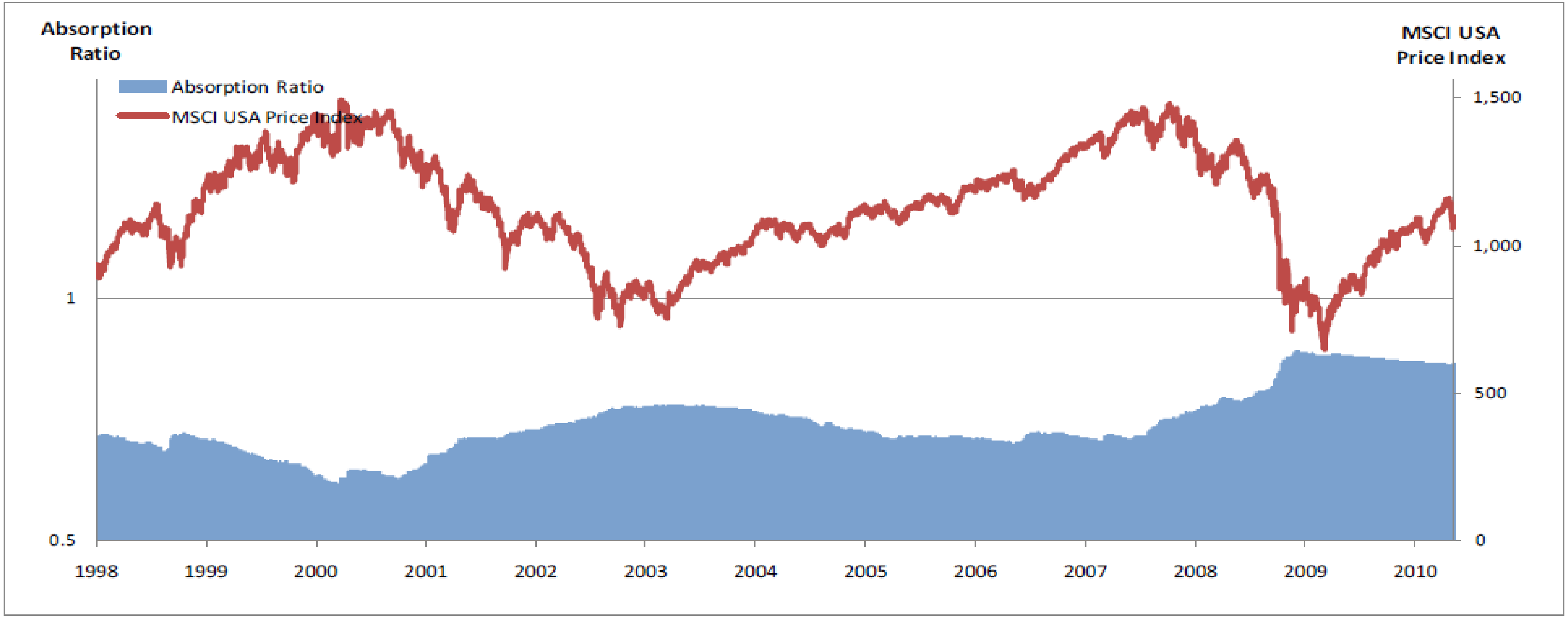
$\sigma_{E_i}^2$ = variance of the i-th eigenvector

$\sigma_{A_j}^2$ = variance of the j-th asset

Kritzman et al 2010 examined the variance of returns of 51 industries that make up the MSCI index from January 1, 1998 through January 31, 2010. They began by calculating an eigenvector that explains the largest proportion of the assets' total variance. They then proceeded to calculate another orthogonal eigenvector that explains the next greatest proportion of the assets' total variance. This process is continued for a total of ten eigenvectors as described in [1].

Absorption Ratio vs MSCI USA Index

(From [1] Kritzman et al 2010, reprinted in accordance with permissions detailed in page 1 of manuscript) © Mark Kritzman, Yuanzhen Li, Sebastien Page, and Roberto Rigobon.



(Kritzman et al 2010) [1] briefly mentions the appearance of an inverse relationship between the absorption ratio and stock prices. However, the focus the 2010 study was not this countercyclical relationship but rather the association between spikes in the AR and market downturns. They explain that as AR rapidly rises markets become more tightly coupled. This greater susceptibility to shocks means the probability of a large market drop is more likely when AR spikes upward is high.

Assumptions of the Information Processing (R/C) Model

The economy can be modeled as a large information processing and communicating machine.

Assume economic actors serve as limited and imperfect intermediaries between raw input information and the final output information of the economy.

Economic actors have finite computational and communication bandwidth

Economic actors introduce errors into the computation and communication of information processed in the economy

These computational and communication limitations result in the loss of information or entropy growth (Ben-Naim 2017 interpretation of Shannon Entropy vs Thermodynamic Entropy -closed system entropy cannot grow)

The conventional yield curve can be reinterpreted as a rate needed to balance the total loss of information or entropy growth over time.

The variable R/C derived from the above assumptions where:

R/C = Information to be processed/Capacity to process the information

The Entropic Yield Curve

$$r_{parker} = B_0 + \frac{\ln\left(\sqrt{t}\right)}{t}\left(1 - e^{-C_1\left(1-\frac{R}{C}\right)}\right) - \frac{ln(\sigma)}{t}\left(e^{-C_1\left(1-\frac{R}{C}\right)}\right)$$

$\frac{R}{C}$ is the implied relative information processing rate

The loss of information or the growth of entropy in the economy is assumed to arise from two primary sources. These sources are the natural decay of the current set of information about the economy over time and a non-zero error in the processing of that current information set. This interplay of information diffusion and processing errors determines the total entropy of an economy. The entropic yield curve defines the average growth rate of entropy at any time *t*.

Derivation of the Entropic Yield Curve

$$P_t = P_0\sqrt{t};\ I_t = I_0\sqrt{t}$$ Information and prices assumed to follow Brownian type process

$$\frac{P_t}{P_0} = \frac{I_t}{I_0}$$ Ratio consistent with (Ross's 1989) no arbitrage arguments

$$P_t = P_0 e^{rt};\ \frac{P_t}{P_0} = e^{rt}$$ Standard intertemporal price assumptions

$$e^{rt} = \frac{I_0\sqrt{t}}{I_0},$$ Substituting $\frac{P_t}{P_0} = e^{rt}$ and $I_t = I_0\sqrt{t}$ into the ratio

$$e^{rt} = \sqrt{t}$$

$$r = \frac{ln\sqrt{t}}{t}$$

No Communication or Computational Errors

$$r = \frac{ln\sqrt{t}}{t}$$

Errorless information processing and communication

Assume a computational error and/or processing lag affects the price response

(Ross 1989) assumptions of perfect price and information correlation are relaxed

$$P_t = \frac{P_0}{\sigma}\sqrt{t};\ I_t = I_0\sqrt{t}$$

Error term σ could be magnifies or suppresses price diffusion

$$e^{rt} = \frac{\sqrt{t}}{\sigma}$$

Solve as before in the perfect correlation example

$$rt = ln\sqrt{t} - ln\sigma$$

$$r = \frac{ln\sqrt{t}}{t} - \frac{ln\sigma}{t}$$

$$r = (1-p)\frac{ln\sqrt{t}}{t} - p\ \frac{ln\sigma}{t}$$

The weighting *p* is the probability of an error;
Parker 2017 interpreted in terms of Kullback-Leibler Divergence.

Burnashev Error Exponent

1976 Burnashev published the groundbreaking result

$$p = e^{-C_1\left(1-\frac{R}{C}\right)}$$

Where *R* is a transmitted message and *C* is the channel capacity of the transmitter

Burnashev's Error Exponent is used as the weighting between the true and error distribution in the Entropic Yield Curve

$$r = \left(1 - e^{-C_1\left(1-\frac{R}{C}\right)}\right)\frac{ln\left(\sqrt{t}\right)}{t} - \left(e^{-C_1\left(1-\frac{R}{C}\right)}\right)\frac{\ln(\sigma)}{t}$$

Computing R/C Daily Bond Yield Rates

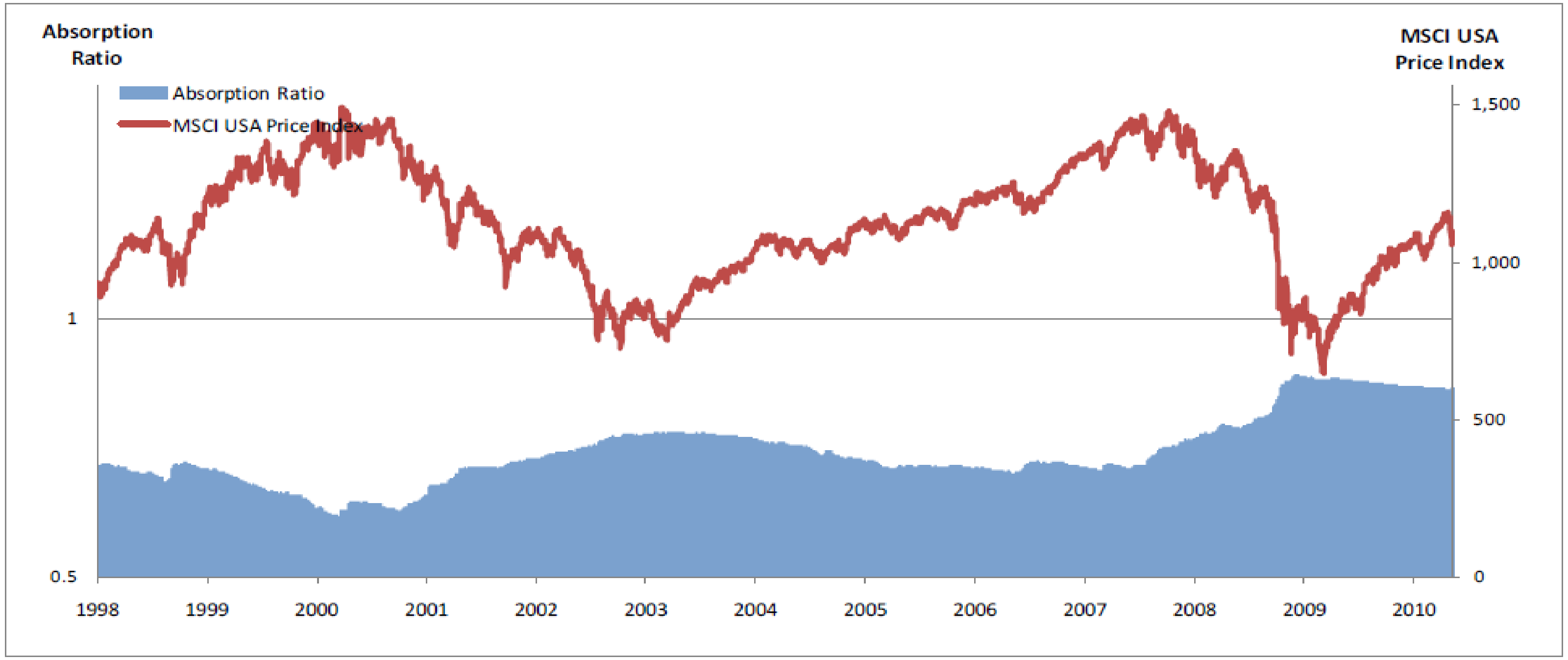
$$r = \left(1 - e^{-C_1\left(1-\frac{R}{C}\right)}\right)\frac{ln\left(\sqrt{t}\right)}{t} - \left(e^{-C_1\left(1-\frac{R}{C}\right)}\right)\frac{\ln(\sigma)}{t}$$

The Implied Information Processing Rate (IIPR) or (*R/C*) can be estimated by matching the entropic yield curve to the observed yields in the markets and then solving for IIPR. This was Accomplished by inputting the daily yield curve rates into the equation above and solving for the R/C value which minimized RMSE of the computed rates vs the actual rates.

The simple excel file with the macro and data are available at the link in the paper.

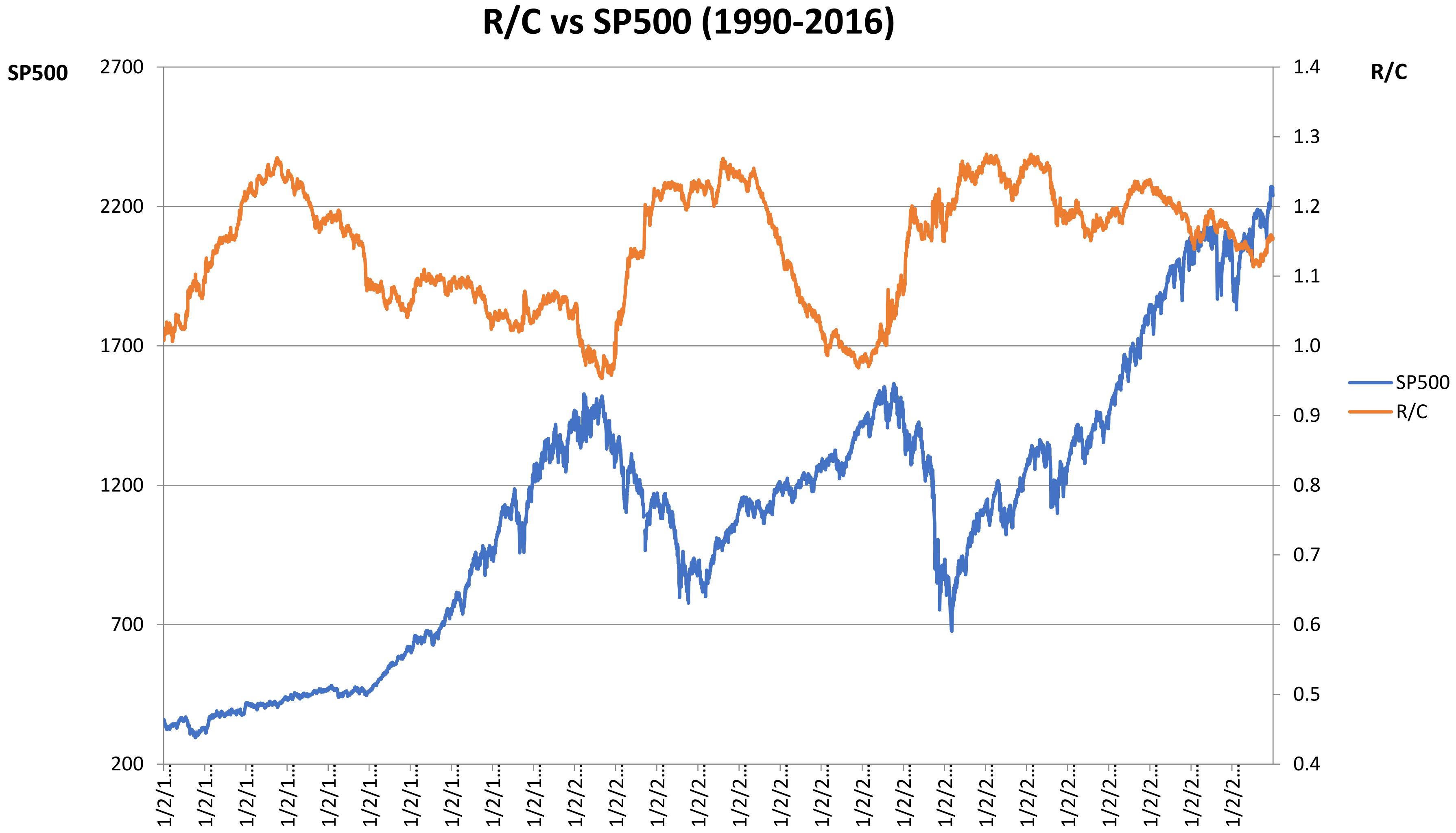
Absorption Ratio(top) vs Information Processing Ratio(bottom)

Absorption Ratio vs MSCI (Large Cap Equities) [1]



Both AR and R/C Display same Countercyclical Trend vs Equities

Information Processing Ratio vs SP500 (Large Cap Equities) [2]



Thus R/C provides a potential explanation of the AR trended cycle. As described in [3] high levels R/C correspond to periods when the economy is fully organized around a new technology and is ready to begin effectively "mining" the amply available data. At higher levels of R/C the volatility of R/C was seen to be lower. The measures may reinforce confidence in risk assessment assumptions when in agreement. When in disagreement the measures may point to the potential of arbitrage opportunities. These opportunities may include capital structure arbitrage type strategies.

The Relationship between the US economy's Information Processing and Absorption Ratio's

References:

1. Kritzman, Mark, Yaunzhen Li, Sebastien Page, and Roberto Rigobon. *Principal Components as a Measure of Systemic Risk.* MIT Sloan School Working Paper 4785-10, 2010.

2. Parker, E. The Entropic Linkage between Equity and Bond Market Dynamics. Entropy 2017, 19, 292.

3. Parker, E. Entropy, The Information Processing Cycle, and the Forecasting of Bull and Bear Market Peaks and Troughs. 2017 (Under Review) Draft available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3037578