



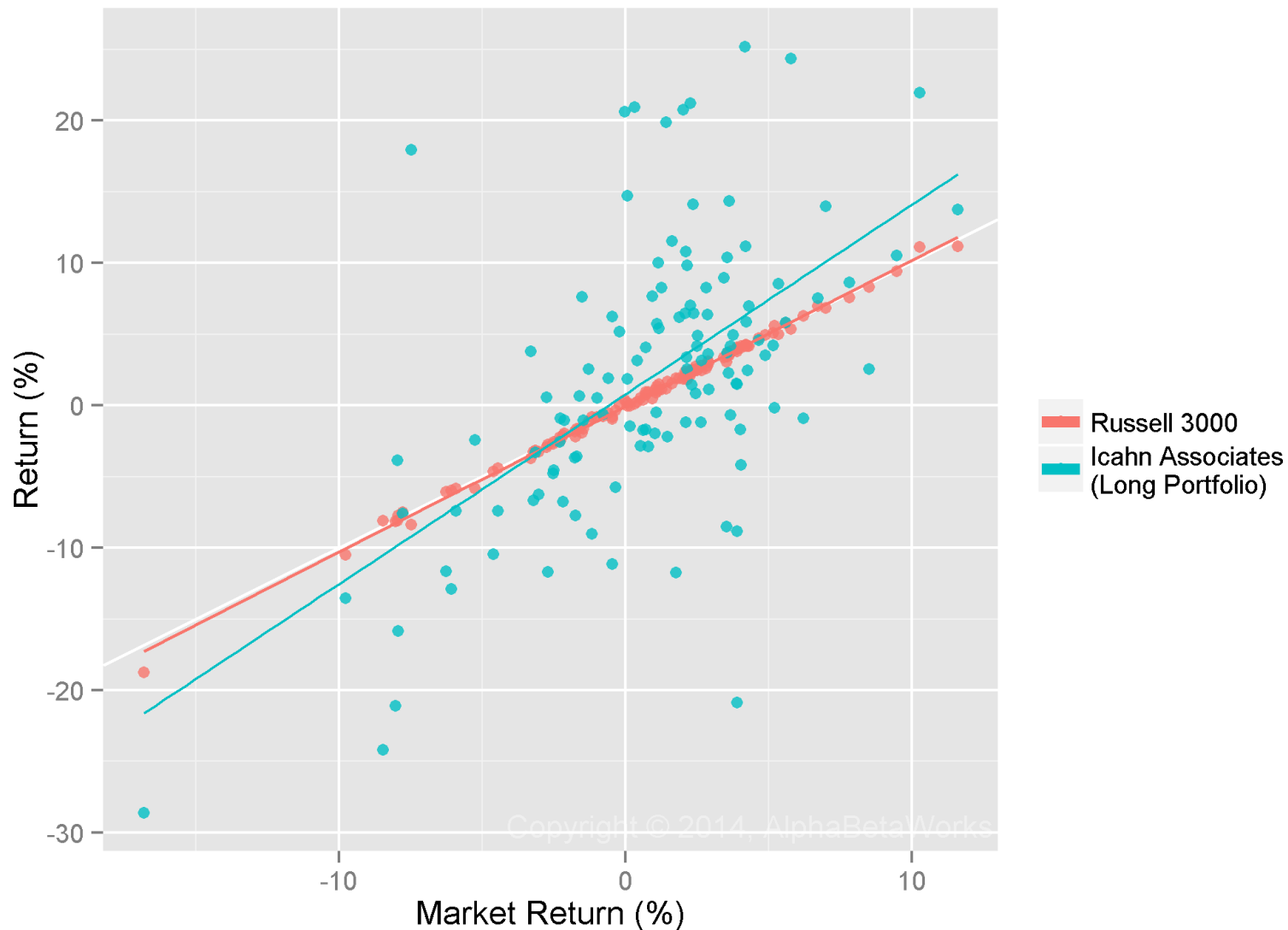
Using R to Characterize Hedge Fund Clustering

Greg Kapoustin, Principal

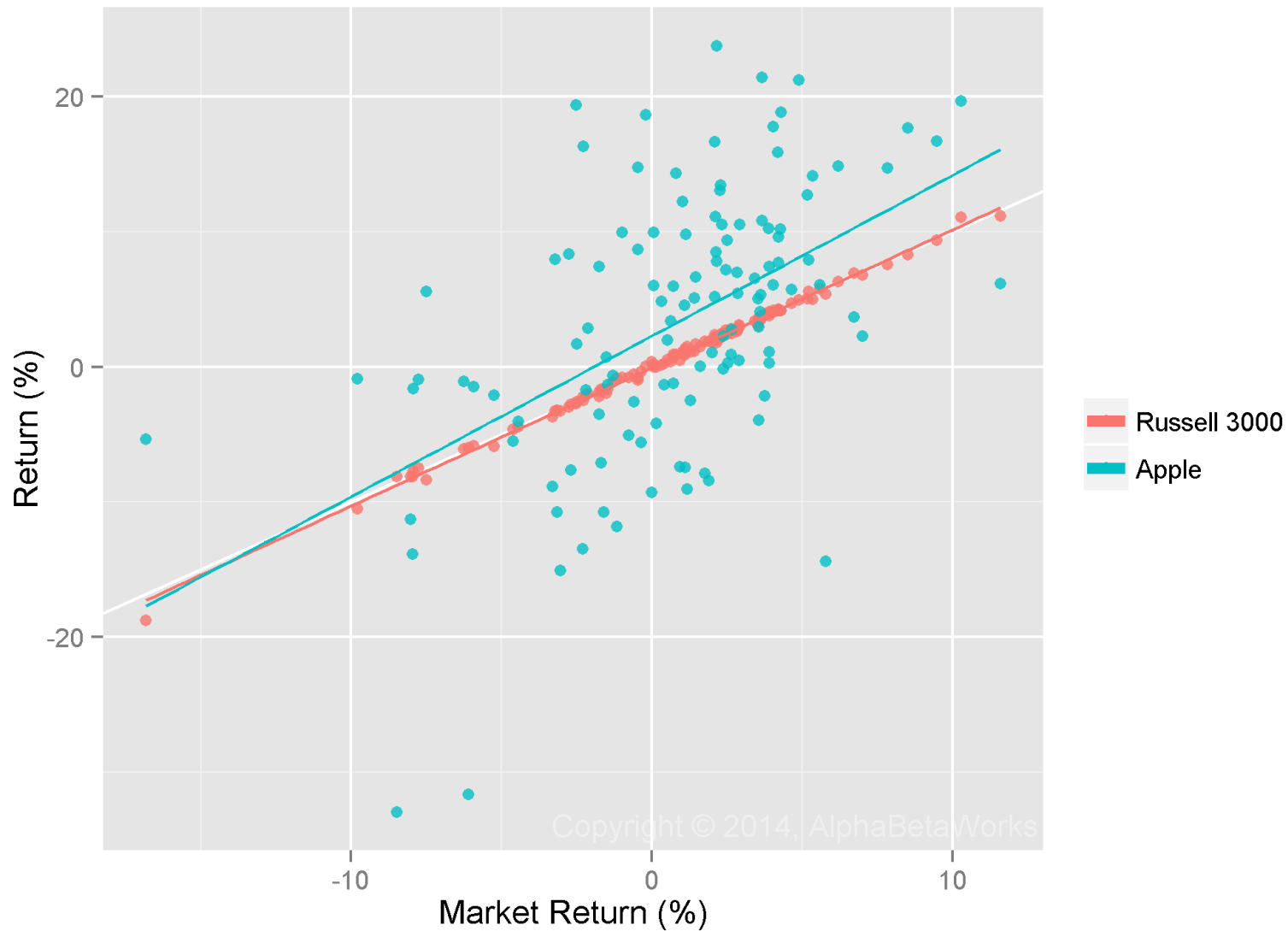
AlphaBetaWorks

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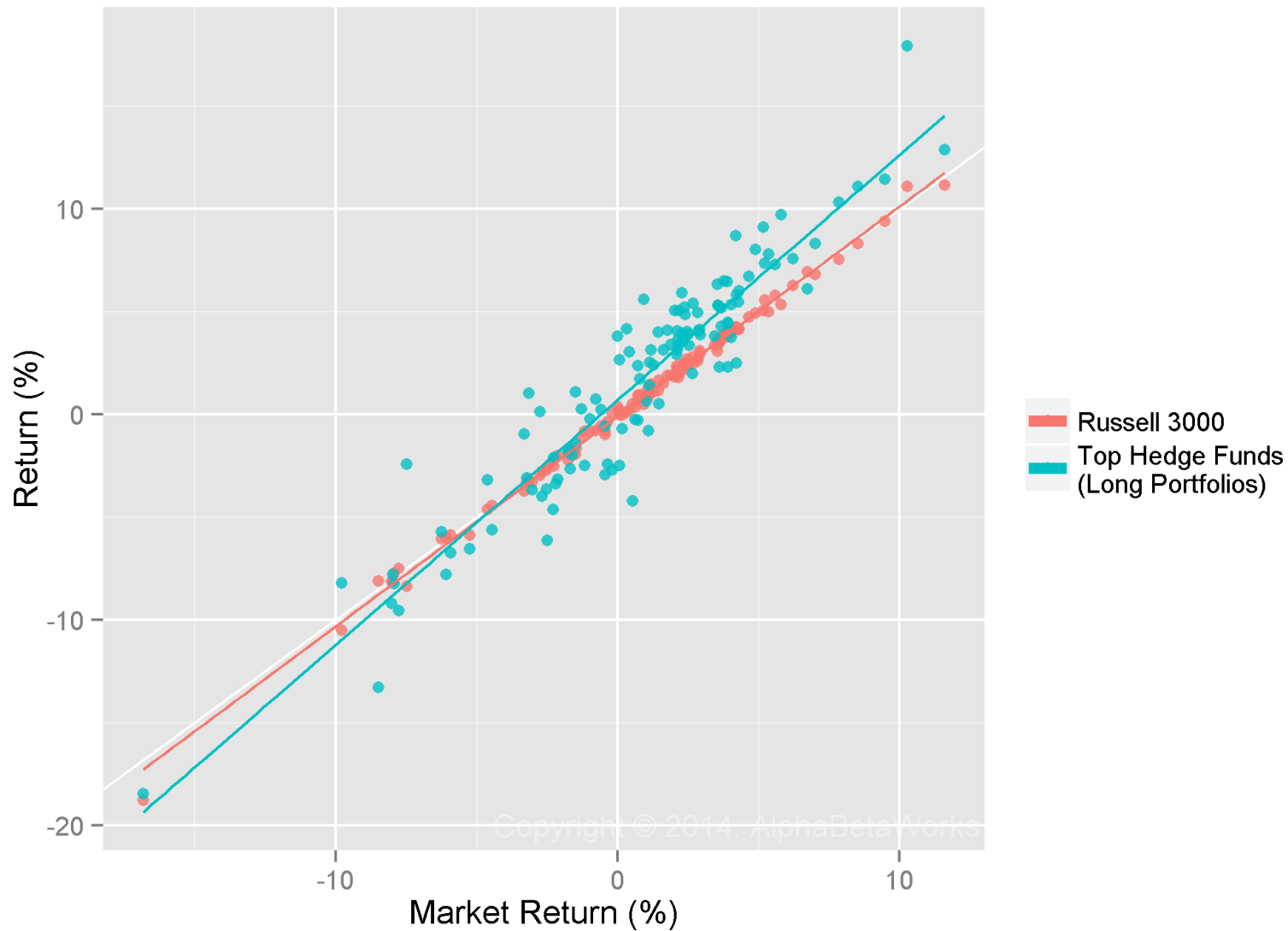
Why do Hedge Funds Exist?



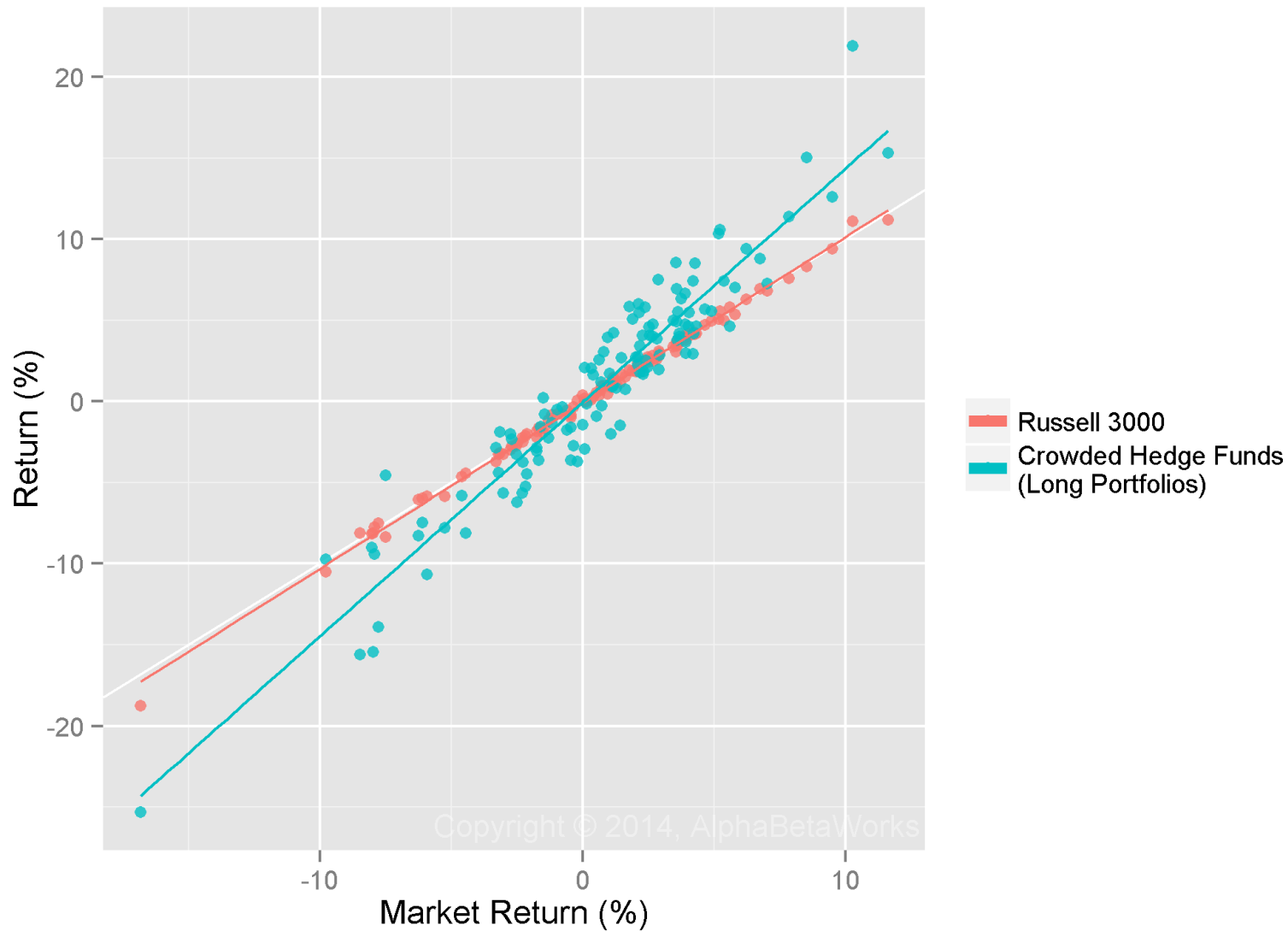
What is Alpha?



What Investors Want



What Investors (Often) Get



Put Differently

What Investors Want



What Investors Get



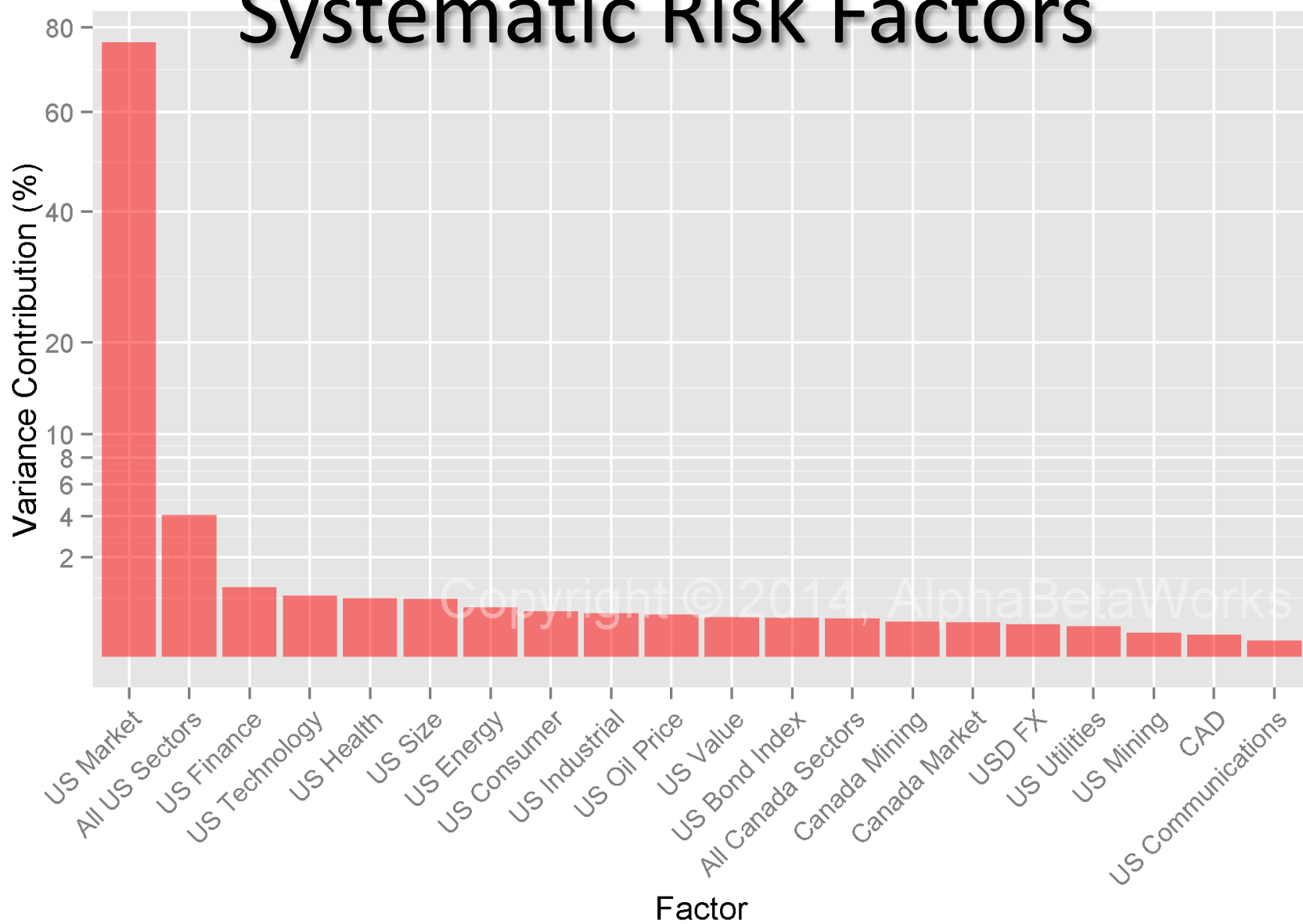
Volatility as Distance

$$\sigma_p = \sqrt{\sum_{i=1}^n \sum_{j=1}^n w_i w_j \sigma_i \sigma_j \rho_{ij}}$$

$\sigma_i \sigma_i \rho_{ii} = \sigma_i^2$ is the variance of asset i

$\sigma_i \sigma_j \rho_{ij} = \sigma(i, j)$ is the covariance between assets i and j .

Systematic Risk Factors





Estimating Factor Exposure

```
# Exponentially weight observations:
# decay constant (0.02) (36 month ~50% decay)
kExpWeights <- exp(-1 * c(1:kDefaultRegPeriods) * .02)

# Estimate exposures using iterated re-weighted least squares (IWLS)
# Default psi = psi.huber
library(MASS)
rlm(
  y ~ x1 + x2 + x3,
  weights = head(kExpWeights, length(y)),
  acc = 0.01,
  na.action = na.fail
)
```

sMed.X Team optimized the `rlm()` critical path for AlphaBetaWorks:

- Rewrote QR decomposition in MASS, currently implemented in FORTRAN, called through a C wrapper:

```
c original (dqrdc.f) linpack version dated 08/14/78 .
c g.w. stewart, university of maryland, argonne national lab.
c
c this version dated 22 august 1995
c ross ihaka
c
c bug fixes 29 September 1999 BDR (p > n case, inaccurate ranks)
```

- Added support of a response matrix in a call to `rlm()`, eliminating the call loop.
- Rewrote the QR algorithm in CUDA-optimized code.
- Achieved >200x performance gain on consumer hardware (\$130 NVIDIA GTX 750Ti).

Factor and Residual Distances

$$\sigma_p = \sqrt{\sum_{i=1}^n \sum_{j=1}^n w_i w_j \sigma_i \sigma_j \rho_{ij}}$$

$$= \sqrt{\sum_{i=1}^n w_i^2 \sigma_{residual_i}^2 + \sum_{i=1}^f \sum_{j=1}^f w_i w_j \sigma_i \sigma_j \rho_{ij}}$$



Portfolio Distance Function

```
PortfolioPairTrackingError <- function(port1, port2) {  
  
  # Calculate relative security weightings  
  pos1 <- port1$pos.last[which(port1$pos.last != 0)]  
  pos2 <- port2$pos.last[which(port2$pos.last != 0)]  
  secs1 <- names(pos1)  
  secs2 <- names(pos2)  
  secs <- union(secs1, secs2)  
  port <- vector("numeric", length(secs))  
  names(port) <- secs  
  port[secs1] <- pos1[secs1]  
  port[secs2] <- port[secs2] - pos2[secs2]  
  
  # Calculate relative residual variance  
  var.resid <- sum(port ^ 2 * risk.model$sec.info[secs, "ResidVar"])  
  
  # Calculate relative factor variance  
  fact.exps <- port1$fact.exps.last - port2$fact.exps.last  
  fact.exp.mat <- fact.exps %*% fact.exps  
  var.fact <- sum(fact.exp.mat * risk.model$fact.cov.mat)  
  
  return(sqrt(var.resid + var.fact))  
}
```



Calculating Pairwise Distances

```
library(doParallel)

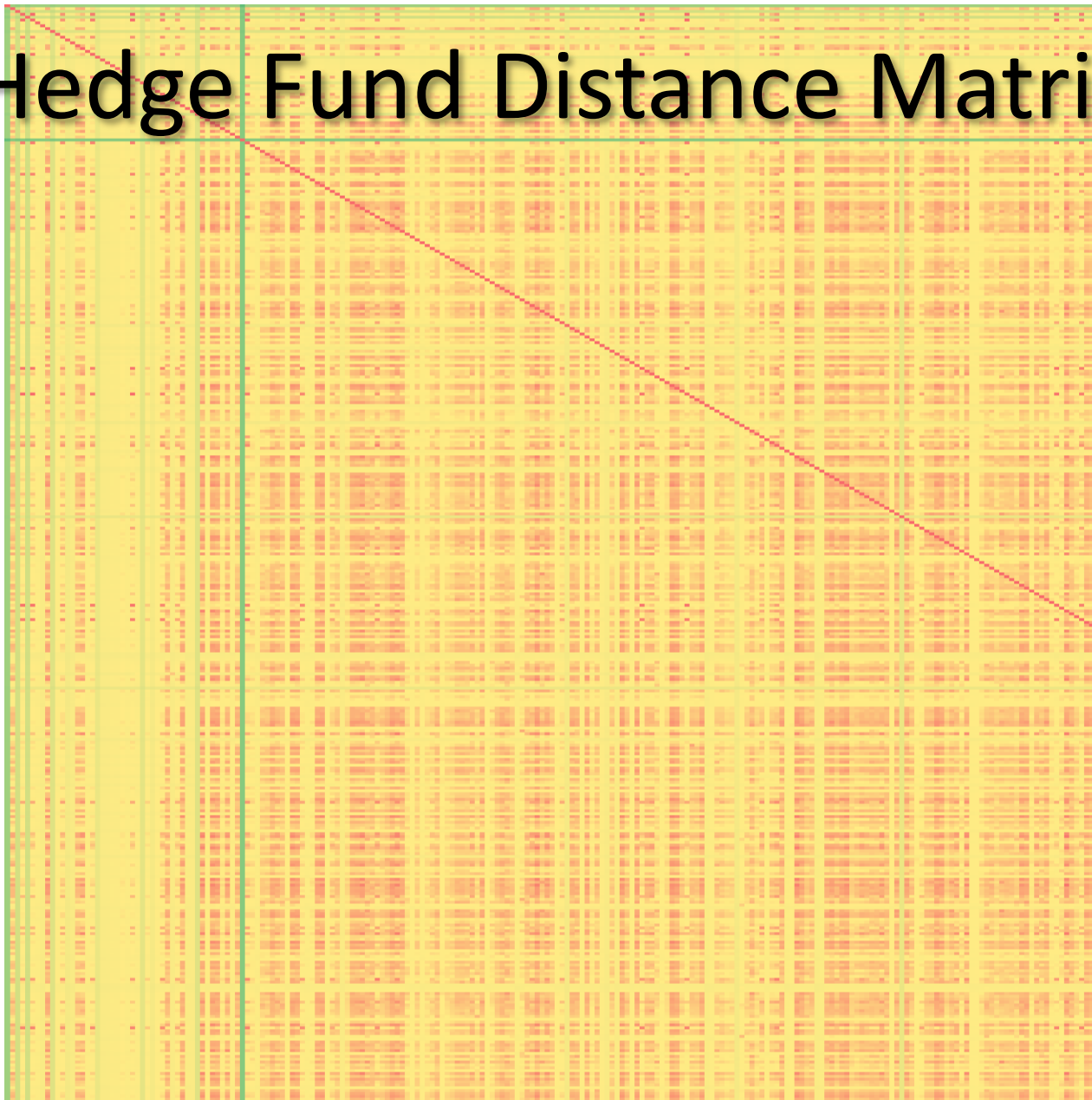
n.workers <- 36
# Empty outfile allows forked STDOUT to
# show up in parent's STDOUT.
cl <- makeCluster(n.workers, outfile = "")

registerDoParallel(cl)

# Source data is accessed via global variables.
tracking.errors <- foreach(
  port.pair = port.pairs,
  .combine = c,
  .errorhandling = 'stop',
  .verbose = TRUE
) %dopar% PortfolioPairTrackingError(
  portfolios[[port.pair$p1]],
  portfolios[[port.pair$p2]]
)

stopCluster(cl)
```

Hedge Fund Distance Matrix





Visualizing the Distance Matrix

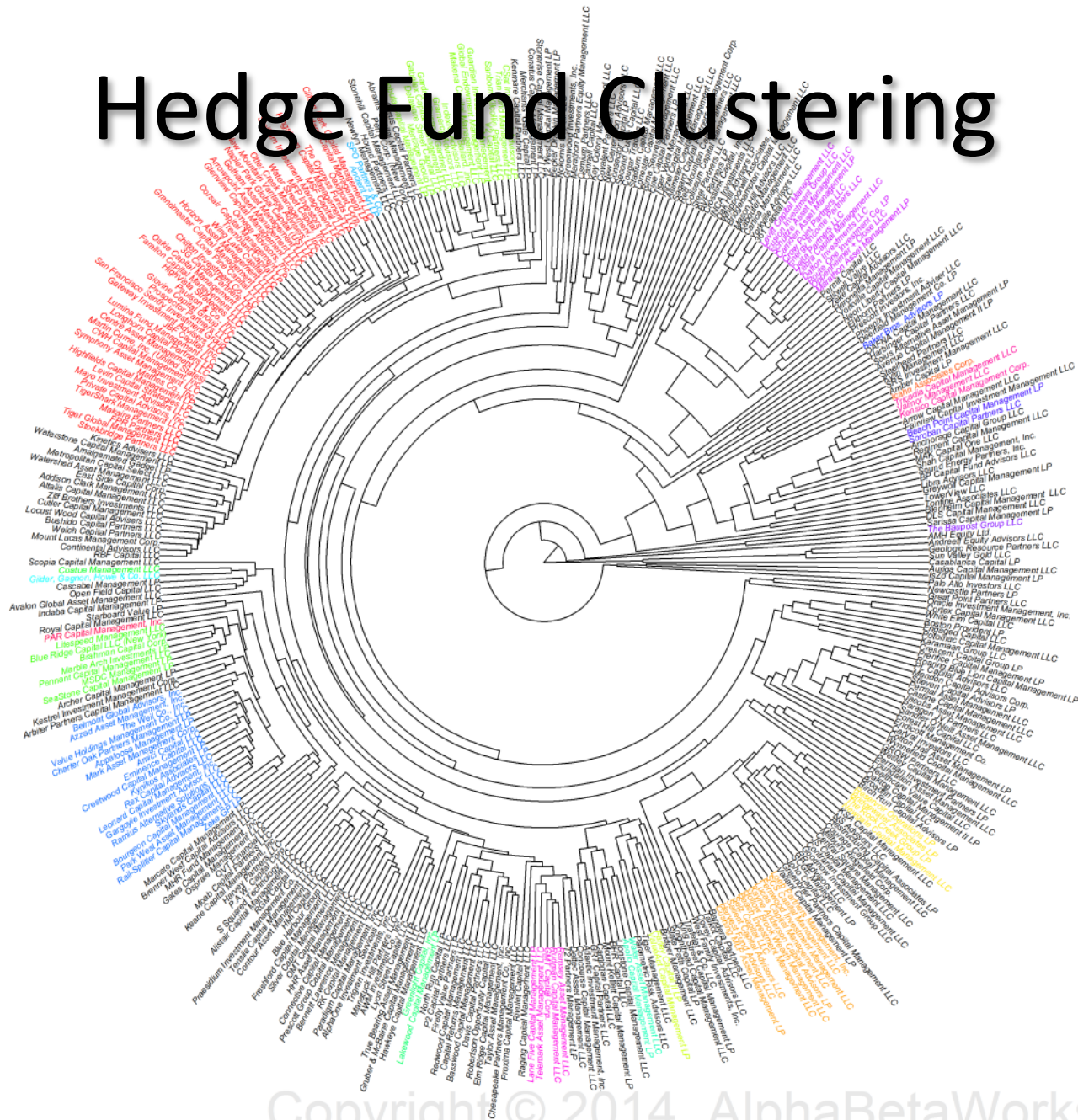
```
# Convert tracking error matrix to distance matrix
plot.d.mat <- as.dist(plot.mat)

# Create clusters
hc <- hclust(plot.d.mat, method = "complete")

# Cut dendrogram cut at h = 10.
# Creates clusters with <= 10% relative tracking errors
clus = cutree(hc, h = 10)

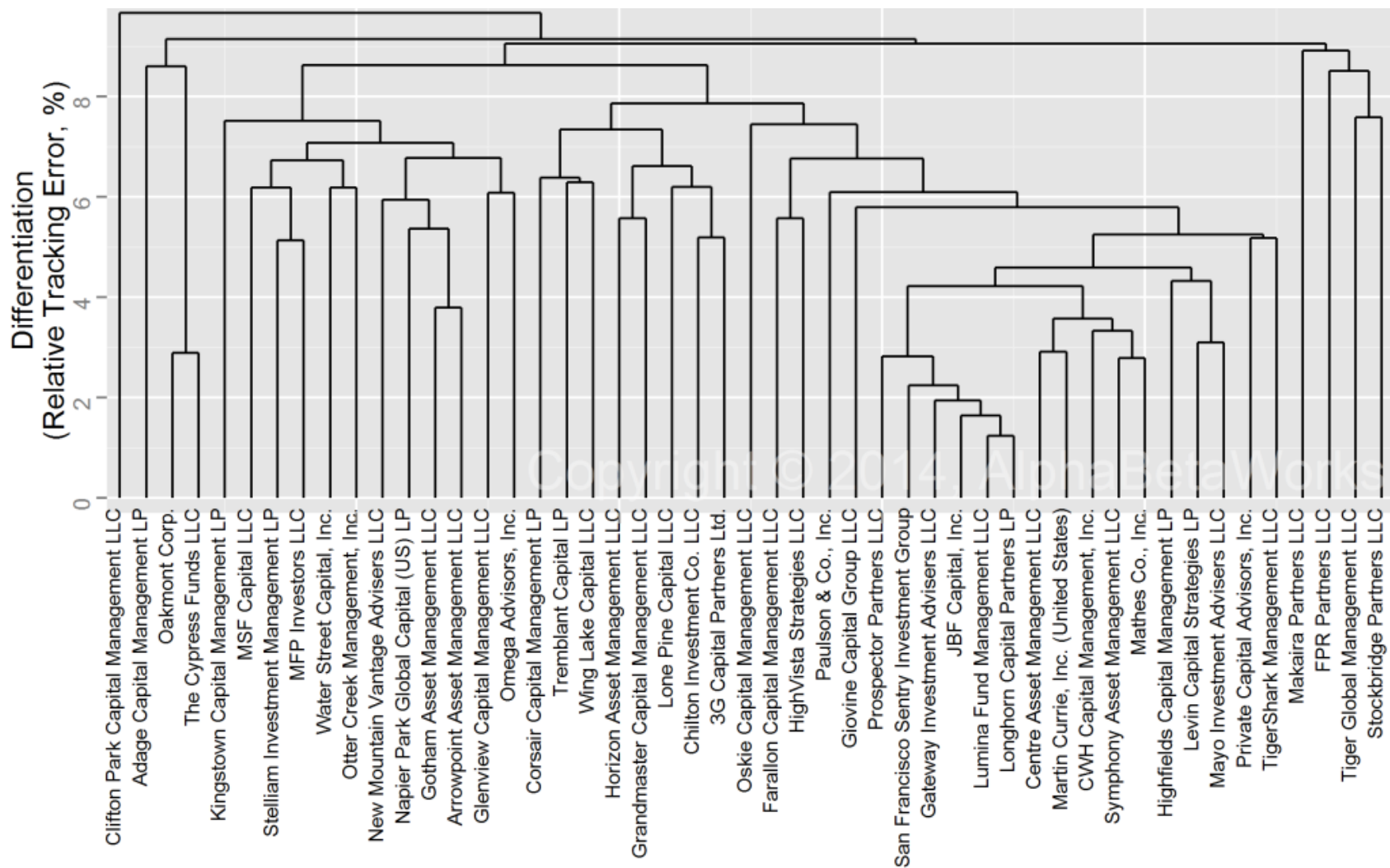
# Plot phylogenetic tree of hedge fund portfolios
pal <- rainbow(20)
plot(
  as.phylo(hc),
  type = "fan",
  cex = 0.5,
  tip.color = pal[clus],
  label.offset = 0.01
)
```

Hedge Fund Clustering



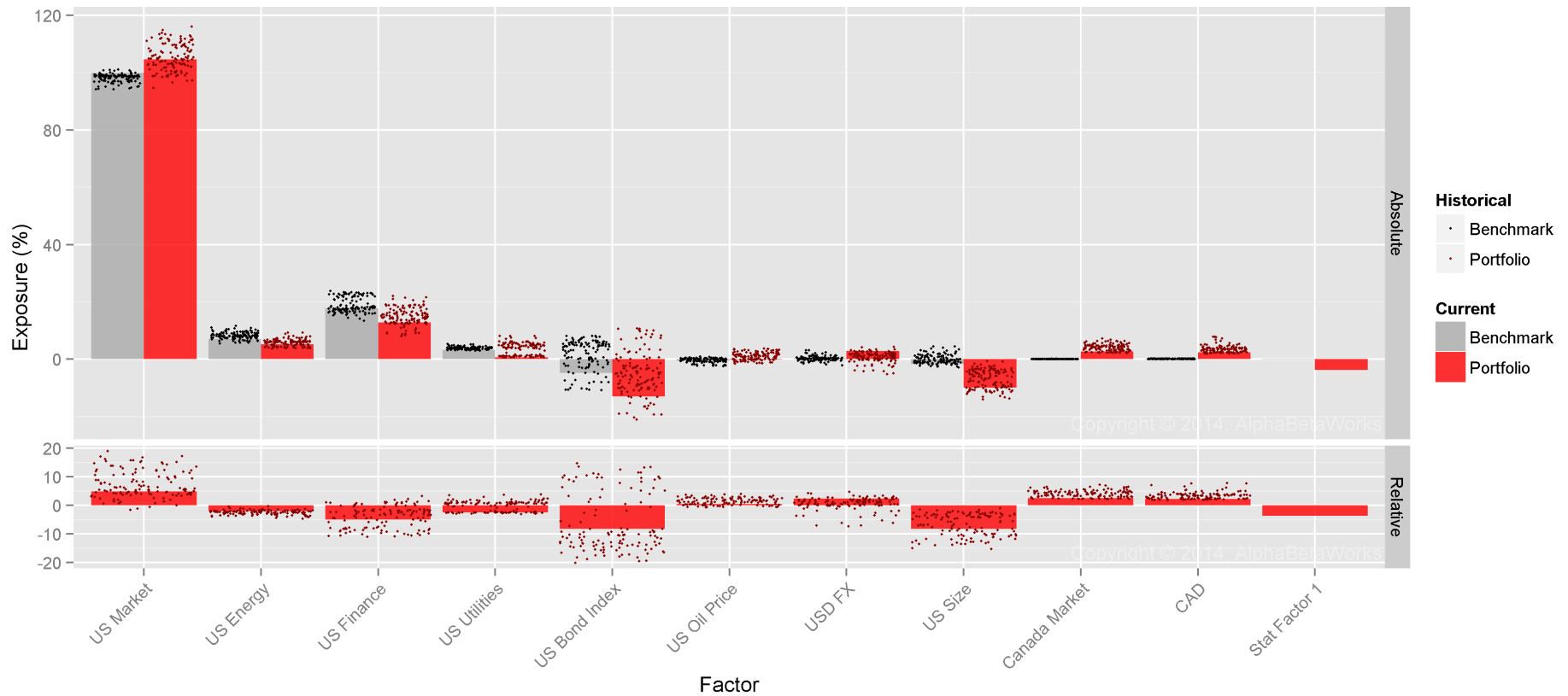


Hedge Fund Cluster

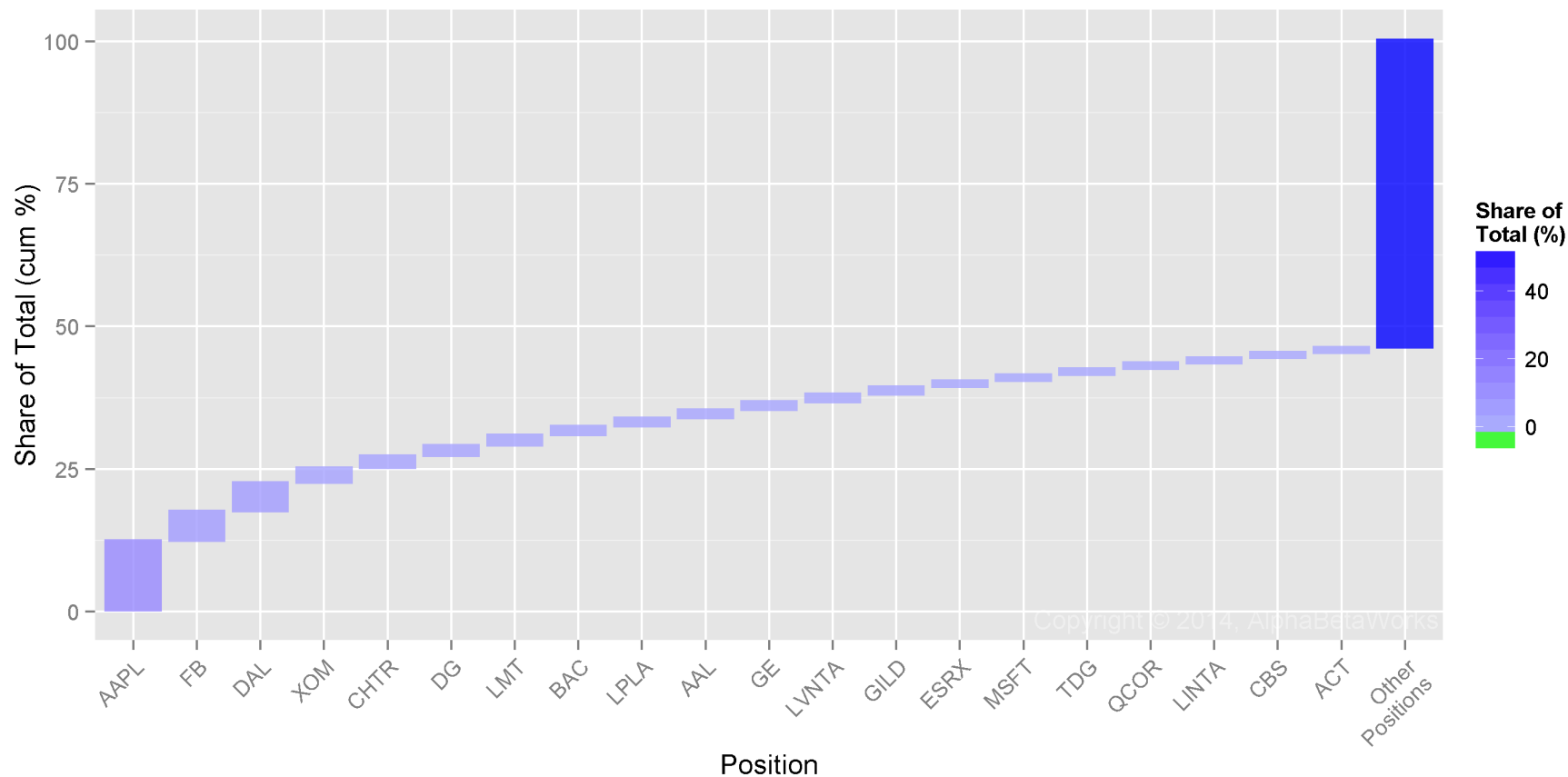




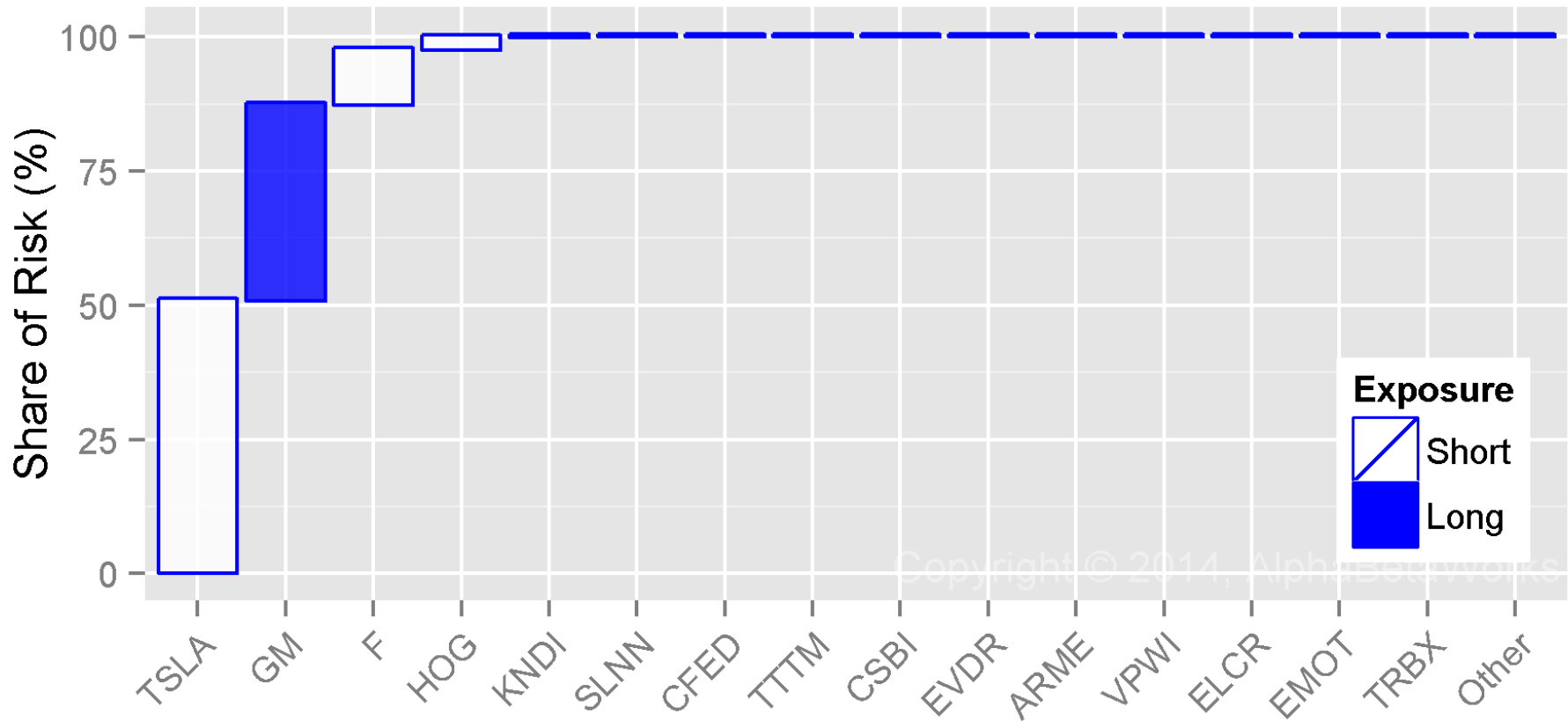
Cluster's Factor Bets



Cluster's Residual Bets



Scary Cluster





Thank You!



Resources

- Wikipedia. *Modern portfolio theory*.
http://en.wikipedia.org/wiki/Modern_portfolio_theory
- Steve Weston and Rich Calaway (2014, February 26). *Getting Started with doParallel and foreach*.
<http://cran.r-project.org/web/packages/doParallel/vignettes/gettingstartedParallel.pdf>
- Steve Weston (2014, April 10). *Using the foreach Package*.
<http://cran.r-project.org/web/packages/foreach/vignettes/foreach.pdf>
- AlphaBetaWorks (2014, October 20). *Hedge Fund Clustering*.
<http://abwinsights.com/2014/10/20/hedge-fund-clustering/>
- AlphaBetaWorks Insights and AlphaBetaWorks Charts.
Examples of Financial Analytics in R.
<http://abwinsights.com>
<http://abwcharts.com>



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