"Time Series Momentum, a replication"

(draft)

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2021-06-25

Abstract

This document includes replication material on some academic and practitioners' literature instrumental for our RGSoC 2020 project. The document itself is meant to be completely reproducible.

Introduction

Moskowitz, Ooi, and Pedersen [2] (MOP hereafter) study an asset pricing anomaly they name *time series momentum*, which is related but different from the *momentum* effect in that the latter has a cross-sectional relative nature with respect to assets clusters while the former is directly linked with single assets returns. They find the anomaly consistent both across different asset classes and markets. Also, they confirm this effect to be robust among more illiquid instruments.

Data and methodology

TODO: Present data series we used, compare with analogies and differences with respect to data authors used.

The cross-section of time series momentum

The excess returns

$$\frac{r_t^s}{\sigma_{t-1}^s} = \alpha + \beta_h \frac{r_{t-h}^s}{\sigma_{t-h-1}^s} + \epsilon_t^s$$

where assets returns are scaled by their ex-ante volatility σ_{t-1}^s, with annualized variance being

$$\sigma_t^2 = 261 \sum_{i=0}^{\infty} (1-\delta)\delta^i (r_{t-i-1} - \bar{r}_t)^2$$

$\bar{r}_t$ returns exponentially weighted moving average (EWMA) and weight δ so that $\delta/(1-\delta) = 60$ days. Returns of TSMOM trading strategies on the instrument s at month t are systematically obtained considering the excess returns sign of s over the past k months and then acquiring or selling the instrument during the subsequent h months. These two parameters determine a family of TSMOM strategies and are called *lookback period* and *holding period*, respectively.
It follows that the strategy return at time t, defined $r_t^{\text{TSMOM}(k,h)}$, represents the average return across all instrument portfolios at that time, i.e. the return on the portfolio that was constructed in all observable past months. These returns are then average across all instruments include or within each asset class.

To explain these returns and assess whether they held abnormal performance, Moskowitz, Ooi, and Pedersen [2] study the regression specification

$$r_t^{\text{TSMOM}(k,h)} = \alpha + \beta_1 MSCI_t + \beta_2 GSCI_t + \beta_3 BOND_t + \beta_4 SMB_t + \beta_5 HML_t + \beta_6 UMD_t + \epsilon_t$$

where $MSCI$ is the MSCI World Index, $GSCI$ the S&P Goldman Sachs Commodity Index, $BOND$ is Barclay's Aggregate Bond Index (Bloomberg Barclays Global Aggregate Index at the time of writing) and SMB, HML, UMD are the usual Fama-French-Carhart factors. In what follows, given data series availability from authors, we study the TSMOM strategy with a 12 months lookback period and holding period of a month, that is $r_t^{\text{TSMOM}(12,1)}$, for each asset class and in the all assets aggregate.

```
# TSM portfolios
parser.path <- file.path('inst', 'parsers', 'TSM.R')
source(parser.path)
TSM <- xts::xts(TSM[, -1], order.by=TSM$DATE)
# MSCI
parser.path <- file.path('inst', 'parsers', 'MSCI-WI.R')
source(parser.path)
# NOTE:
# - in place of 'GSCI' we use 'CM.MARKET'
# - in place of 'BOND' we use 'FI.MARKET'
parser.path <- file.path('inst', 'parsers', 'CFP.R')
source(parser.path)
CM.MARKET <- CFP[, 'CM.MARKET']
FI.MARKET <- CFP[, 'FI.MARKET']
# VME
parser.path <- file.path('inst', 'parsers', 'VME-Factors.R')
source(parser.path)
VME.FACTORS <- VME.Factors[, c('VAL.EVR', 'MOM.EVR')]
# FFC factors
FF3 <- ExpectedReturns::GetFactors('FF3', freq='monthly')
MOM <- ExpectedReturns::GetFactors('MOM', freq='monthly')
min.tp <- max(first(index(FF3)), first(index(MOM)))
max.tp <- min(last(index(FF3)), last(index(MOM)))
days.diff <- diff(seq.Date(min.tp, max.tp, by='month'))[-1]
ff.dates <- c(min.tp, min.tp + cumsum(as.numeric(days.diff)))
# VIX Index
parser.path <- file.path('inst', 'parsers', 'VIX-FRED.R')
source(parser.path)
#> Registered S3 method overwritten by 'quantmod':
#>   method            from
#>   as.zoo.data.frame zoo
VIX.RET <- VIX.cls.monthly$VIX.RET
# VIX Index top ~20% extremes
vix20idxs <- order(
  abs(VIX.RET$VIX.RET), decreasing=TRUE
)[1:round(nrow(VIX.RET) * 0.2)]
VIX20 <- VIX.RET[vix20idxs, ]
colnames(VIX20) <- 'VIX.TOP.20'
# TED Spread
parser.path <- file.path('inst', 'parsers', 'TED-Spread.R')
source(parser.path)
colnames(TED.SPREAD) <- 'TED'
# TED Spread top ~20% extremes
ted20idxs <- order(
  abs(TED.SPREAD$TED), decreasing=TRUE
)[1:round(nrow(TED.SPREAD) * 0.2)]
TED20 <- TED.SPREAD[ted20idxs, ]
colnames(TED20) <- 'TED.TOP.20'
```

```r
# FFC4 factors
FFC4 <- merge(FF3[ff.dates, ], MOM[ff.dates, ])
# MSCI World Index
data <- merge(MSCI.WI$RET, FFC4)
data$MSCI.RET <- zoo::na.locf(data$RET)
data$MSCI.RF <- data$MSCI.RET - data$RF
data$RET <- NULL

# Bonds factors data
# data <- merge(CRP, data)
# data$GOVT.XS <- na.fill(data$GOVT.XS, c(NA, 'extend', NA))
# data$CORP.XS <- na.fill(data$CORP.XS, c(NA, 'extend', NA))
# Convert data set
# data <- data.frame(
#   DATE=ff.dates,
#   data[ff.dates, c(colnames(CRP), 'MSCI.RF', colnames(FFC4))],
#   row.names=NULL
# )
# tp <- 1:max(which(!is.na(data$CORP.XS)))
# data <- data[tp, ]

# Bonds factor
data <- merge(data, FI.MARKET)
# Commodities Market
data <- merge(data, CM.MARKET)
# VME factors
data <- merge(data, VME.FACTORS)
# VIX Index
data <- merge(data, VIX.RET)
# TED Spread
data <- merge(data, TED.SPREAD)
# TSMOM(12, 1) strategy returns
data <- merge(data, TSM)

# NOTE:
# All series are considered relative to FF dates, which are at month-end.
# Usually a dates mismatch of one day can exist around the month-end, for reasons
# among which publication date discrepancies or subsequent corrections.
# When this happens we simply consider last available values with respect to the
# month-end, as those are dates most series we work with refer to.
data <- zoo::na.locf(data)
# NOTE:
# TED-Spread and VIX top ~20% series are used as they are constructed
data <- merge(data, TED20, VIX20)

data <- data.frame(
  DATE=ff.dates,
  data[ff.dates, ],
  row.names=NULL
)
```

```r
# Indexes
date.id <- matrix(1:nrow(data), dimnames=list(NULL, 'DATE.ID'))
data <- cbind(data, date.id)
```

```r
# The period used in the paper for running the time series regression is Jan 1985 - Dec 2009
# The AQR website TSMOM portfolios from which we sourced our data for this replication start # reportin
# replicating the time period in the paper, we will need to truncate the 'data' object after # Dec 2009
# we do. For the updated alpha t-stats the user can comment this line of code.
data <- data[-((which(data$DATE=="2009-12-31")+1):nrow(data)),]
# Regressions variables
y <- colnames(TSM)
X <- c('MSCI.RF', 'CM.MARKET', 'FI.MARKET', 'SMB', 'HML', 'MOM')
# Time-series regressions
tsmom.ts.reg <- lapply(1:length(y), function(x) {
  model.formula <- formula(
    paste(
      y[x], paste(X, collapse='+'),
      sep='~'
    )
  )
  plm::plm(
    model.formula, data=data,
    model='pooling', index='DATE.ID'
  )
})
lapply(tsmom.ts.reg, summary)
#> [[1]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.10932029 -0.01970851  0.00022208  0.02319636  0.11269611
#>
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0106637  0.0018451  5.7796 1.914e-08 ***
#> MSCI.RF      0.0013660  0.0421579  0.0324    0.9742
#> CM.MARKET    0.0354209  0.0512053  0.6917    0.4896
#> FI.MARKET    0.8315999  0.1468966  5.6611 3.584e-08 ***
#> SMB         -0.0244645  0.0569914 -0.4293    0.6680
#> HML         -0.0861596  0.0639061 -1.3482    0.1786
#> MOM          0.2466065  0.0372565  6.6191 1.719e-10 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.35494
#> Residual Sum of Squares: 0.27412
#> R-Squared:      0.22771
#> Adj. R-Squared: 0.21189
#> F-statistic: 14.3985 on 6 and 293 DF, p-value: 2.1581e-14
#>
```

```
#> [[2]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.1096122 -0.0248001  0.0010091  0.0239814  0.1304815
#>
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0110224  0.0023262  4.7383 3.364e-06 ***
#> MSCI.RF     -0.0647233  0.0531517 -1.2177 0.2243147
#> CM.MARKET    0.0605353  0.0645585  0.9377 0.3491807
#> FI.MARKET    0.0142585  0.1852039  0.0770 0.9386857
#> SMB         -0.0301398  0.0718535 -0.4195 0.6751861
#> HML         -0.1094120  0.0805713 -1.3580 0.1755234
#> MOM          0.1774182  0.0469722  3.7771 0.0001922 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.46836
#> Residual Sum of Squares: 0.43573
#> R-Squared:      0.069671
#> Adj. R-Squared: 0.05062
#> F-statistic: 3.65708 on 6 and 293 DF, p-value: 0.0016182
#>
#> [[3]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.2544612 -0.0484728  0.0010889  0.0471823  0.2333885
#>
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0138097  0.0044723  3.0878  0.002209 **
#> MSCI.RF      0.3086792  0.1021877  3.0207  0.002744 **
#> CM.MARKET   -0.1096949  0.1241180 -0.8838  0.377531
#> FI.MARKET    0.6434716  0.3560668  1.8072  0.071762 .
#> SMB          0.0861594  0.1381430  0.6237  0.533312
#> HML         -0.1447340  0.1549036 -0.9343  0.350893
#> MOM          0.6255245  0.0903071  6.9266 2.736e-11 ***
```

```
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    1.9776
#> Residual Sum of Squares: 1.6106
#> R-Squared:      0.1856
#> Adj. R-Squared: 0.16893
#> F-statistic: 11.1293 on 6 and 293 DF, p-value: 3.467e-11
#>
#> [[4]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.2785190 -0.0345310 -0.0025833  0.0397867  0.2938477
#>
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0070762  0.0044659  1.5845  0.114156
#> MSCI.RF     -0.1211310  0.1020415 -1.1871  0.236159
#> CM.MARKET    0.2423726  0.1239404  1.9556  0.051468 .
#> FI.MARKET    3.4420614  0.3555575  9.6807 < 2.2e-16 ***
#> SMB         -0.0756377  0.1379454 -0.5483  0.583892
#> HML          0.0161682  0.1546820  0.1045  0.916824
#> MOM          0.2433162  0.0901779  2.6982  0.007376 **
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    2.1926
#> Residual Sum of Squares: 1.606
#> R-Squared:      0.26754
#> Adj. R-Squared: 0.25254
#> F-statistic: 17.8369 on 6 and 293 DF, p-value: < 2.22e-16
#>
#> [[5]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.1838140 -0.0320387  0.0015488  0.0313781  0.1801250
#>
```

```
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0112898  0.0032065  3.5208 0.0004987 ***
#> MSCI.RF      0.0348571  0.0732667  0.4758 0.6346030
#> CM.MARKET   -0.0706179  0.0889904 -0.7935 0.4281025
#> FI.MARKET    0.1201060  0.2552935  0.4705 0.6383745
#> SMB         -0.0507800  0.0990461 -0.5127 0.6085540
#> HML         -0.0640848  0.1110631 -0.5770 0.5643742
#> MOM          0.1347483  0.0647486  2.0811 0.0382929 *
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.84707
#> Residual Sum of Squares: 0.82793
#> R-Squared:      0.022594
#> Adj. R-Squared: 0.0025786
#> F-statistic: 1.12883 on 6 and 293 DF, p-value: 0.34543
```

```
# NOTE:
# for the last three models we run regressions on monthly series as opposed to
# quarterly data.
y <- 'TSMOM' # diversified TSMOM(12,1)
X <- list(
  ffc4.msci=c('MSCI.RF', 'SMB', 'HML', 'MOM')
  , amp3=c('MSCI.RF', 'VAL.EVR', 'MOM.EVR')
  , msci=c('MSCI.RF', 'I(MSCI.RF^2)')
  , ted=c('TED')
  , ted20=c('TED.TOP.20')
  , vix=c('VIX.RET')
  , vix20=c('VIX.TOP.20')
)
tsmom.div.ts.reg <- lapply(X, function(x) {
  model.formula <- formula(
    paste(
      y, paste(x, collapse='+'),
      sep='~'
    )
  )
  plm::plm(
    model.formula, data=data,
    model='pooling', index='DATE.ID'
  )
})
lapply(tsmom.div.ts.reg, summary)
#> $ffc4.msci
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
```

```
#>      Min.   1st Qu.    Median   3rd Qu.      Max.
#> -0.091379 -0.020234 -0.000232  0.022107  0.096558
#>
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0124964  0.0018997  6.5781 2.167e-10 ***
#> MSCI.RF      0.0453268  0.0423667  1.0699    0.2856
#> SMB         -0.0464467  0.0596205 -0.7790    0.4366
#> HML         -0.0543627  0.0665797 -0.8165    0.4149
#> MOM          0.2604649  0.0390151  6.6760 1.217e-10 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.35494
#> Residual Sum of Squares: 0.30417
#> R-Squared:      0.14304
#> Adj. R-Squared: 0.13142
#> F-statistic: 12.3101 on 4 and 295 DF, p-value: 2.8573e-09
#>
#> $amp3
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.06615202 -0.01659133  0.00011689  0.01636553  0.09776698
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0069494  0.0016701  4.1612 4.154e-05 ***
#> MSCI.RF     0.1020819  0.0337809  3.0219  0.002732 **
#> VAL.EVR     0.5249948  0.1187016  4.4228 1.370e-05 ***
#> MOM.EVR     1.3058855  0.0956993 13.6457 < 2.2e-16 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.35494
#> Residual Sum of Squares: 0.19829
#> R-Squared:      0.44134
#> Adj. R-Squared: 0.43568
#> F-statistic: 77.9456 on 3 and 296 DF, p-value: < 2.22e-16
#>
#> $msci
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
```

```
#>
#> Balanced Panel: n = 300, T = 1, N = 300
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.13495967 -0.02101905  0.00051154  0.02454996  0.09230257
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.012700   0.002291  5.5431 6.562e-08 ***
#> MSCI.RF      0.015940   0.046452  0.3431    0.7317
#> I(MSCI.RF^2) 0.614991   0.502156  1.2247    0.2217
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.35494
#> Residual Sum of Squares: 0.35315
#> R-Squared:      0.0050584
#> Adj. R-Squared: -0.0016415
#> F-statistic: 0.754997 on 2 and 297 DF, p-value: 0.47091
#>
#> $ted
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 288, T = 1, N = 288
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.11722709 -0.02166841  0.00045997  0.02402124  0.09598502
#>
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0147248  0.0036399  4.0453 6.727e-05 ***
#> TED         -0.1382778  0.4418099 -0.3130    0.7545
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.34114
#> Residual Sum of Squares: 0.34102
#> R-Squared:      0.00034239
#> Adj. R-Squared: -0.0031529
#> F-statistic: 0.0979567 on 1 and 286 DF, p-value: 0.75452
#>
#> $ted20
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
```

```
#>
#> Balanced Panel: n = 61, T = 1, N = 61
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.0648855 -0.0261318 -0.0057107  0.0238100  0.0848548
#>
#> Coefficients:
#>              Estimate Std. Error t-value Pr(>|t|)
#> (Intercept)  0.018497   0.013913  1.3294   0.1888
#> TED.TOP.20  -0.228504   1.046491 -0.2184   0.8279
#>
#> Total Sum of Squares:    0.082348
#> Residual Sum of Squares: 0.082282
#> R-Squared:      0.00080744
#> Adj. R-Squared: -0.016128
#> F-statistic: 0.0476777 on 1 and 59 DF, p-value: 0.82791
#>
#> $vix
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 239, T = 1, N = 239
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.08516055 -0.02325105  0.00095976  0.02264952  0.09185705
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0132976  0.0022215  5.9859 7.906e-09 ***
#> VIX.RET     0.0111164  0.0123396  0.9009    0.3686
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.27885
#> Residual Sum of Squares: 0.2779
#> R-Squared:      0.0034127
#> Adj. R-Squared: -0.0007923
#> F-statistic: 0.811582 on 1 and 237 DF, p-value: 0.36857
#>
#> $vix20
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 27, T = 1, N = 27
#>
```

```
#> Residuals:
#>      Min.   1st Qu.    Median   3rd Qu.      Max.
#> -0.074446 -0.035838 -0.010089  0.037357  0.099514
#>
#> Coefficients:
#>              Estimate Std. Error t-value Pr(>|t|)
#> (Intercept) 0.0066779  0.0125105  0.5338   0.5982
#> VIX.TOP.20  0.0086264  0.0303570  0.2842   0.7786
#>
#> Total Sum of Squares:    0.063628
#> Residual Sum of Squares: 0.063423
#> R-Squared:      0.0032196
#> Adj. R-Squared: -0.036652
#> F-statistic: 0.0807488 on 1 and 25 DF, p-value: 0.77863
```

Time series momentum factor

Let us consider the TSMOM(12, 1) strategy, aggregating returns across all asset classes holds a portfolio called *diversified TSMOM factor* and expressed as

$$r_{t,t+1}^{\text{TSMOM}} = \frac{1}{S_t} \sum_{s=1}^{S_t} \text{sign}(r_{t-12,t}^s) \frac{40\%}{\sigma_t^s} r_{t,t+1}^s$$

with S_t securities investable at time t and a 40% constant annual volatility is chosen by authors because "it is similar to the risk of an average individual stock" and to "make it easier to intuitively compare our portfolios to other in the literature" as, it is consistent with other factors' volatility once averaged over securities.

Time series momentum vs. cross-sectional momentum

Follow authors, in this section we compare time series momentum and the cross-sectional momentum of Asness, Moskowitz, and Pedersen [1]. Over the comparable sample period, our results are close to the ones authors published. They differ in that often our estimates exhibit heavier loading in direct momentum time-series regressions. In particular, an empirical interpretation of small magnitude signs shifts may be that during the last two to three years sample period analyzed by authors financial markets were rather turbulent. A practical reason for differences is that data series corrections have occurred in authors' updated data sets we are working with. Notwithstanding, t-statistics and R^2 generally appear to be in line with authors' results and this may be confirmatory of the stable relation between the two momentum strategies both across asset classes and over time.

```
# Time series and Cross-sectional Momentum data
XSMOM <- VME.Factors[, c('MOM.AA', 'MOMLS.VME.COM', 'MOMLS.VME.EQ', 'MOMLS.VME.FI', 'MOMLS.VME.FX', 'MOM
colnames(XSMOM) <- c('XSMOM.ALL', 'XSMOM.COM', 'XSMOM.EQ', 'XSMOM.FI', 'XSMOM.FX', 'XSMOM.US') # naming
#XSMOM <- xts::xts(XSMOM[, -1], order.by=XSMOM$DATE)
mom.data <- merge(TSM, XSMOM)
mom.data <- zoo::na.locf(mom.data)
mom.data <- mom.data[xts::endpoints(mom.data), ]
mom.data$DATE.ID <- 1:nrow(mom.data)
# To check out on paper sample period
# mom.data <- mom.data['1985/2009', ]
mom.data <- data.frame(
  DATE=index(mom.data),
  mom.data,
  row.names=NULL
```

```
)
# Time-series regressions
Y <- rep(colnames(TSM), 2)
X.aac <- colnames(XSMOM)[-1]
X <- c(rep(list(X.aac), 5), colnames(XSMOM)[1], as.list(X.aac[-length(X.aac)]))
mom.tsxs.reg <- lapply(1:length(Y), function(x) {
  model.formula <- formula(
    paste(
      Y[x], paste(X[[x]], collapse='+'),
      sep='~'
    )
  )
  plm::plm(
    model.formula, data=mom.data,
    model='pooling', index='DATE.ID'
  )
})
mom.tsxs.reg <- lapply(mom.tsxs.reg, summary)
names(mom.tsxs.reg) <- Y
mom.tsxs.reg
#> $TSMOM
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.0609522 -0.0162001 -0.0010384  0.0150687  0.1219595
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0078135  0.0012256  6.3751 4.720e-10 ***
#> XSMOM.COM   0.2128639  0.0229248  9.2853 < 2.2e-16 ***
#> XSMOM.EQ    0.2255692  0.0431825  5.2236 2.740e-07 ***
#> XSMOM.FI    0.5285577  0.1025023  5.1565 3.845e-07 ***
#> XSMOM.FX    0.5451889  0.0517903 10.5268 < 2.2e-16 ***
#> XSMOM.US    0.1114091  0.0274625  4.0568 5.909e-05 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.55585
#> Residual Sum of Squares: 0.27545
#> R-Squared:      0.50445
#> Adj. R-Squared: 0.49869
#> F-statistic: 87.5442 on 5 and 430 DF, p-value: < 2.22e-16
#>
#> $TSMOM.CM
#> Pooling Model
#>
```

```
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.1460652 -0.0198900 -0.0016059  0.0163222  0.1676099
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0051083  0.0015323  3.3337 0.0009313 ***
#> XSMOM.COM   0.4697595  0.0286619 16.3897 < 2.2e-16 ***
#> XSMOM.EQ    0.0663404  0.0539892  1.2288 0.2198295
#> XSMOM.FI    0.0532622  0.1281540  0.4156 0.6779022
#> XSMOM.FX    0.3077288  0.0647512  4.7525 2.744e-06 ***
#> XSMOM.US    0.0845989  0.0343352  2.4639 0.0141333 *
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.79826
#> Residual Sum of Squares: 0.43057
#> R-Squared:      0.46061
#> Adj. R-Squared: 0.45434
#> F-statistic: 73.4403 on 5 and 430 DF, p-value: < 2.22e-16
#>
#> $TSMOM.EQ
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.3337551 -0.0398917 -0.0041646  0.0413094  0.2856652
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0082162  0.0034914  2.3533  0.019057 *
#> XSMOM.COM   0.1393430  0.0653045  2.1337  0.033429 *
#> XSMOM.EQ    0.6815338  0.1230114  5.5404 5.267e-08 ***
#> XSMOM.FI    0.3749670  0.2919919  1.2842  0.199774
#> XSMOM.FX    0.2400860  0.1475319  1.6273  0.104395
#> XSMOM.US    0.2989812  0.0782308  3.8218  0.000152 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    2.7585
#> Residual Sum of Squares: 2.2352
```

```
#> R-Squared:      0.18971
#> Adj. R-Squared: 0.18029
#> F-statistic: 20.1345 on 5 and 430 DF, p-value: < 2.22e-16
#>
#> $TSMOM.FI
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.2441715 -0.0436279 -0.0042197  0.0407109  0.3200015
#>
#> Coefficients:
#>               Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept)  0.0133711  0.0036744  3.6390 0.0003070 ***
#> XSMOM.COM   -0.0579705  0.0687276 -0.8435 0.3994277
#> XSMOM.EQ     0.4495772  0.1294593  3.4727 0.0005674 ***
#> XSMOM.FI     2.5669268  0.3072973  8.3532 9.234e-16 ***
#> XSMOM.FX     0.0630578  0.1552651  0.4061 0.6848491
#> XSMOM.US     0.1153377  0.0823314  1.4009 0.1619666
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    3.0838
#> Residual Sum of Squares: 2.4757
#> R-Squared:      0.1972
#> Adj. R-Squared: 0.18786
#> F-statistic: 21.1246 on 5 and 430 DF, p-value: < 2.22e-16
#>
#> $TSMOM.FX
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.0915056 -0.0210376 -0.0039625  0.0205443  0.2473895
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0075659  0.0017826  4.2442 2.689e-05 ***
#> XSMOM.COM   0.0298759  0.0333433  0.8960    0.3707
#> XSMOM.EQ    0.0301800  0.0628074  0.4805    0.6311
#> XSMOM.FI    0.0546252  0.1490859  0.3664    0.7142
```

```
#> XSMOM.FX    1.5585737  0.0753272 20.6907 < 2.2e-16 ***
#> XSMOM.US    0.0145366  0.0399433  0.3639    0.7161
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    1.2235
#> Residual Sum of Squares: 0.58271
#> R-Squared:      0.52373
#> Adj. R-Squared: 0.51819
#> F-statistic: 94.5688 on 5 and 430 DF, p-value: < 2.22e-16
#>
#> $TSMOM
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.0600196 -0.0167066 -0.0011624  0.0148769  0.1261860
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0080604  0.0012425  6.4874 2.385e-10 ***
#> XSMOM.ALL   1.6953366  0.0844878 20.0661 < 2.2e-16 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.55585
#> Residual Sum of Squares: 0.28834
#> R-Squared:      0.48126
#> Adj. R-Squared: 0.48007
#> F-statistic: 402.646 on 1 and 434 DF, p-value: < 2.22e-16
#>
#> $TSMOM.CM
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.1753388 -0.0196797 -0.0018296  0.0175890  0.1921494
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0059372  0.0015869  3.7413 0.0002076 ***
```

```
#> XSMOM.COM   0.5026216  0.0291205 17.2600 < 2.2e-16 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    0.79826
#> Residual Sum of Squares: 0.47335
#> R-Squared:      0.40703
#> Adj. R-Squared: 0.40566
#> F-statistic: 297.909 on 1 and 434 DF, p-value: < 2.22e-16
#>
#> $TSMOM.EQ
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.3121405 -0.0390721 -0.0022675  0.0395469  0.2906981
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0093583  0.0035849  2.6105  0.009355 **
#> XSMOM.EQ    0.9484206  0.1159281  8.1811 3.143e-15 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    2.7585
#> Residual Sum of Squares: 2.39
#> R-Squared:      0.13361
#> Adj. R-Squared: 0.13162
#> F-statistic: 66.9306 on 1 and 434 DF, p-value: 3.1429e-15
#>
#> $TSMOM.FI
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.2609282 -0.0433551 -0.0067468  0.0398376  0.2708938
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0154180  0.0037025  4.1642  3.77e-05 ***
#> XSMOM.FI    2.7863015  0.3072226  9.0693 < 2.2e-16 ***
```

```
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    3.0838
#> Residual Sum of Squares: 2.5925
#> R-Squared:      0.15933
#> Adj. R-Squared: 0.15739
#> F-statistic: 82.2527 on 1 and 434 DF, p-value: < 2.22e-16
#>
#> $TSMOM.FX
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = model.formula, data = mom.data, model = "pooling",
#>     index = "DATE.ID")
#>
#> Balanced Panel: n = 436, T = 1, N = 436
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.0913855 -0.0207945 -0.0032619  0.0202135  0.2477614
#>
#> Coefficients:
#>              Estimate Std. Error t-value  Pr(>|t|)
#> (Intercept) 0.0078722  0.0017606  4.4713 9.939e-06 ***
#> XSMOM.FX    1.5805721  0.0726604 21.7529 < 2.2e-16 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    1.2235
#> Residual Sum of Squares: 0.58532
#> R-Squared:      0.5216
#> Adj. R-Squared: 0.5205
#> F-statistic: 473.187 on 1 and 434 DF, p-value: < 2.22e-16
```

Next, we try to gain insights on what factors better explain time-series momentum.

```
## Panel C
# NOTE: 'DJCS MF' and 'DJCS MACRO' data missing
data <- merge(
  data,
  data.frame(
    DATE=XSMOM[, 1],
    XSMOM[, -1],
    row.names=NULL
  )
)
Y <- c('XSMOM.ALL', 'XSMOM.COM', 'XSMOM.EQ', 'XSMOM.FI', 'XSMOM.FX', 'SMB', 'HML', 'MOM')
tsmom.div.all <- lapply(Y, function(y) {
  plm::plm(
    formula(paste(y, 'TSMOM', sep='~')),
    data=data, model='pooling', index='DATE.ID'
  )
})
```

```
lapply(tsmom.div.all, summary)
#> [[1]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.05133061 -0.00757821  0.00072138  0.00884176  0.04286071
#>
#> Coefficients:
#>               Estimate Std. Error t-value Pr(>|t|)
#> (Intercept) 1.7815e-03 4.2870e-05  41.557   <2e-16 ***
#> TSMOM       1.0850e-18 1.1537e-03   0.000        1
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    29.859
#> Residual Sum of Squares: 29.859
#> R-Squared:      4.8317e-39
#> Adj. R-Squared: -7.2623e-06
#> F-statistic: 8.84501e-31 on 1 and 137698 DF, p-value: 1
#>
#> [[2]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.2560735 -0.0306383  0.0025132  0.0317759  0.2170347
#>
#> Coefficients:
#>                Estimate  Std. Error t-value Pr(>|t|)
#> (Intercept)  4.1064e-03  1.5799e-04  25.992   <2e-16 ***
#> TSMOM       -5.7640e-19  4.2517e-03   0.000        1
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    405.52
#> Residual Sum of Squares: 405.52
#> R-Squared:      NA
#> Adj. R-Squared: NA
#> F-statistic: 1.83795e-32 on 1 and 137698 DF, p-value: 1
#>
```

```
#> [[3]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.14434271 -0.01685222 -0.00046838  0.01954785  0.10743509
#>
#> Coefficients:
#>               Estimate Std. Error t-value Pr(>|t|)
#> (Intercept) 4.2236e-03 8.9957e-05  46.951   <2e-16 ***
#> TSMOM       2.1448e-18 2.4209e-03   0.000        1
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    131.47
#> Residual Sum of Squares: 131.47
#> R-Squared:      NA
#> Adj. R-Squared: NA
#> F-statistic: 7.84919e-31 on 1 and 137698 DF, p-value: 1
#>
#> [[4]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.05199527 -0.00620176  0.00012183  0.00574418  0.06356147
#>
#> Coefficients:
#>                Estimate  Std. Error t-value Pr(>|t|)
#> (Intercept)  4.5293e-04  3.8558e-05  11.747   <2e-16 ***
#> TSMOM       -7.6315e-19  1.0376e-03   0.000        1
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    24.154
#> Residual Sum of Squares: 24.154
#> R-Squared:      3.5228e-37
#> Adj. R-Squared: -7.2623e-06
#> F-statistic: 5.40911e-31 on 1 and 137698 DF, p-value: 1
#>
#> [[5]]
```

```
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.0845797 -0.0120295  0.0010703  0.0161056  0.0791314
#>
#> Coefficients:
#>               Estimate Std. Error t-value Pr(>|t|)
#> (Intercept) 1.3371e-03 6.9383e-05  19.271   <2e-16 ***
#> TSMOM       9.8285e-19 1.8672e-03   0.000        1
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    78.212
#> Residual Sum of Squares: 78.212
#> R-Squared:      NA
#> Adj. R-Squared: NA
#> F-statistic: 2.77078e-31 on 1 and 137698 DF, p-value: 1
#>
#> [[6]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.16897223 -0.01844740 -0.00077796  0.01840207  0.21150259
#>
#> Coefficients:
#>                Estimate  Std. Error t-value Pr(>|t|)
#> (Intercept)  5.2969e-04  9.6486e-05  5.4898 4.03e-08 ***
#> TSMOM       -6.9485e-03  2.5966e-03 -2.6761  0.00745 **
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    151.26
#> Residual Sum of Squares: 151.25
#> R-Squared:      5.2005e-05
#> Adj. R-Squared: 4.4743e-05
#> F-statistic: 7.1613 on 1 and 137698 DF, p-value: 0.0074502
#>
#> [[7]]
#> Pooling Model
```

```
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>        Min.     1st Qu.      Median     3rd Qu.        Max.
#> -0.11527047 -0.01771694 -0.00052578  0.01739190  0.12470549
#>
#> Coefficients:
#>               Estimate  Std. Error t-value  Pr(>|t|)
#> (Intercept)  4.3167e-03  8.9016e-05  48.494 < 2.2e-16 ***
#> TSMOM       -9.2850e-02  2.3955e-03 -38.759 < 2.2e-16 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    130.14
#> Residual Sum of Squares: 128.74
#> R-Squared:      0.010792
#> Adj. R-Squared: 0.010785
#> F-statistic: 1502.28 on 1 and 137698 DF, p-value: < 2.22e-16
#>
#> [[8]]
#> Pooling Model
#>
#> Call:
#> plm::plm(formula = formula(paste(y, "TSMOM", sep = "~")), data = data,
#>     model = "pooling", index = "DATE.ID")
#>
#> Balanced Panel: n = 300, T = 459, N = 137700
#>
#> Residuals:
#>       Min.    1st Qu.     Median    3rd Qu.       Max.
#> -0.3188412 -0.0170308  0.0022299  0.0249200  0.1748818
#>
#> Coefficients:
#>                Estimate  Std. Error t-value  Pr(>|t|)
#> (Intercept) -0.00136970  0.00013382 -10.235 < 2.2e-16 ***
#> TSMOM        0.52990850  0.00360131 147.143 < 2.2e-16 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Total Sum of Squares:    336.7
#> Residual Sum of Squares: 290.95
#> R-Squared:      0.13587
#> Adj. R-Squared: 0.13587
#> F-statistic: 21651.2 on 1 and 137698 DF, p-value: < 2.22e-16
```

References

[1] Clifford S. Asness, Tobias J. Moskowitz, and Lasse Heje Pedersen. "Value and momentum everywhere". In: *The Journal of Finance* 68.3 (2013), pp. 929–985.

[2] Tobias J Moskowitz, Yao Hua Ooi, and Lasse Heje Pedersen. "Time series momentum". In: *Journal of financial economics* 104.2 (2012), pp. 228–250.