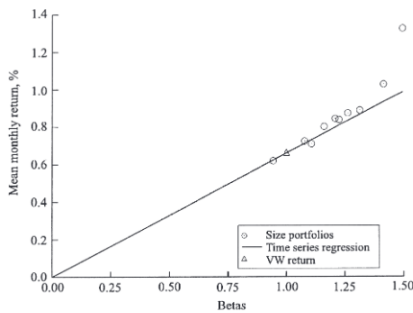


## Question 4

### (a)[3points] CS Regression

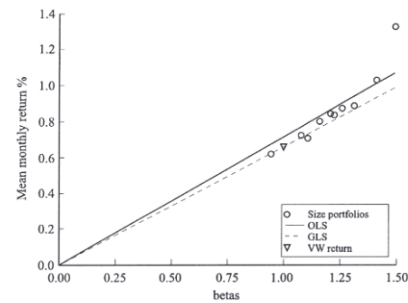
#### Replication of Cochrane, 2009

Write the R code to replicate Figures 15.1 and 15.2 in Cochrane, 2009. Note that these figures use monthly data from 1926 to 1998. Display the two figures you have produced with your R code.



**Figure 15.1.** Average excess returns vs. betas on CRSP size portfolios, 1926–1998. The line gives the predicted average return from the time-series regression,  $E(R^e) = \beta E(R^{em})$ .

(a) A subfigure



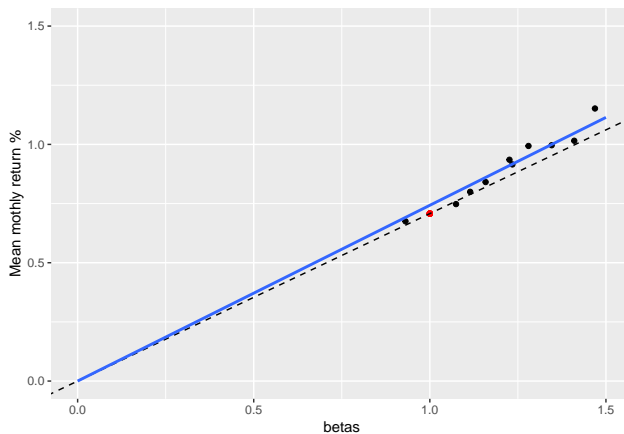
**Figure 15.2.** Average excess returns vs. betas of CRSP size portfolios, 1926–1998, and the fit of cross-sectional regressions.

(b) A subfigure

Figure 1: A figure with two subfigures

Replication of 15.1 time series regression  $E(R^e) = \beta E(R^{em})$ . Set-up of regression analysis:

- download value weighted, size sorted portfolio returns and factors, join tables
- filter data on 1926-1998 time frame
- for each decile calculate excess return  $R_d^e = R_{i,t} - R_{f,t}$
- for each decile, regress  $E[R_d^e] = \beta_d E[R^{me}]$
- plot  $E[R_d^e]$  on  $\beta_d$



The expected excess return-beta is fit precisely on two points  $(\beta, R^e)$ , the market return  $(1, R^{me})$  and the risk-free rate  $(0, 0)$ . It is observed that the smallest size-decile exhibits the largest mean monthly excess return as well as estimated  $\beta$ . The positive pricing error of the TS regression, i.e. the distance between the expected and observed mean monthly excess returns is largest for the smallest size-decile, but smaller than in the original Cochrane figures. The reason for this is unclear, but may be related to adjustments applied on the dataset by French after 2009, or related to data adjustments that were adopted by French but not by Cochrane or vice versa.

## What do these figures tell us about the CAPM?

The largest pricing error in the TS regression occur in the smallest size-decile. This is the small firm anomaly or size premium and is considered a failure of the CAPM. Numerous attempts were made to explain this anomaly: Banz (1981) suggests that small firms face larger cost of capital than large firms which may explain an incentive to merge and form conglomerates. The size effect has been reproduced for numerous sample periods and for most major securities markets around the world (Hawawini and Keim, 2000). However, it tends to be weaker internationally, e.g., Crain (2011) and Bryan (2014). A number of sub-effects have been noted, such as the January-effect, whereby the size premium is observed particularly in the first trading days of the year and is largely absent the rest of the year Reinganum (1981), Roll (1981), Keim (1983), Gu (2003), Easterday, Sen, and Stephan (2009). Additionally, the size effect appears to have weakened significantly since it was first detected in the early 1980s e.g., Dichev (1998), Chan, Karceski, and Lakonishok (2000), Horowitz, Loughran and Savin (2000), Amihud (2002), Schwert (2003) and Van Dijk (2011). The size effect appears to be driven by “extreme” stocks. Removing stocks with less than USD 5m in market cap or alternatively the smallest 5% of firms causes the small firm effect to vanish e.g., Horowitz, Loughran, and Savin (2000), Crain (2011) and Bryan (2014). Additionally, Crain (2011) suggests that size may be a proxy for liquidity. Controlling for firm quality, a robust size effect emerges according to “Size Matters, If You Control Your Junk” by Assness, Frazzini, Israel, Moskowitz, and Pedersen (2015). Quality stocks are safe, profitable, growing, and well managed. Quality is measured using the Quality Minus Junk (QMJ) factor proposed by Asness, Frazzini, and Pedersen (2014).

The extensive research on the size premium undertaken after Cochrane produced the graphs 15.1 and 15.2 in 2009 may explain why the French dataset may control for some of the listed effects.

## (b)[3points] Shanken Correction

replicate the first 3 columns in Table 15.1, and the first 4 columns of Table 15.2 of Cochrane (2005, book)

```
## [1] "matrix" "array"

## # A tibble: 5 x 4
##   Title      TS    OLS    GLS
##   <chr>    <dbl> <dbl> <dbl>
## 1 Estimate 0.708 0.743 0.708
## 2 iid      0.195 0.191 0.195
## 3 0-lag     0.190 0.192 0.190
## 4 3l-NW     0.190 0.192 0.190
## 5 24l       0.189 0.189 0.189
```