```r
#import libraries
library(cobalt)
```

```
##  cobalt (Version 4.4.0, Build Date: 2022-08-13)
```

```r
library(WeightIt)
library(lmtest)
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

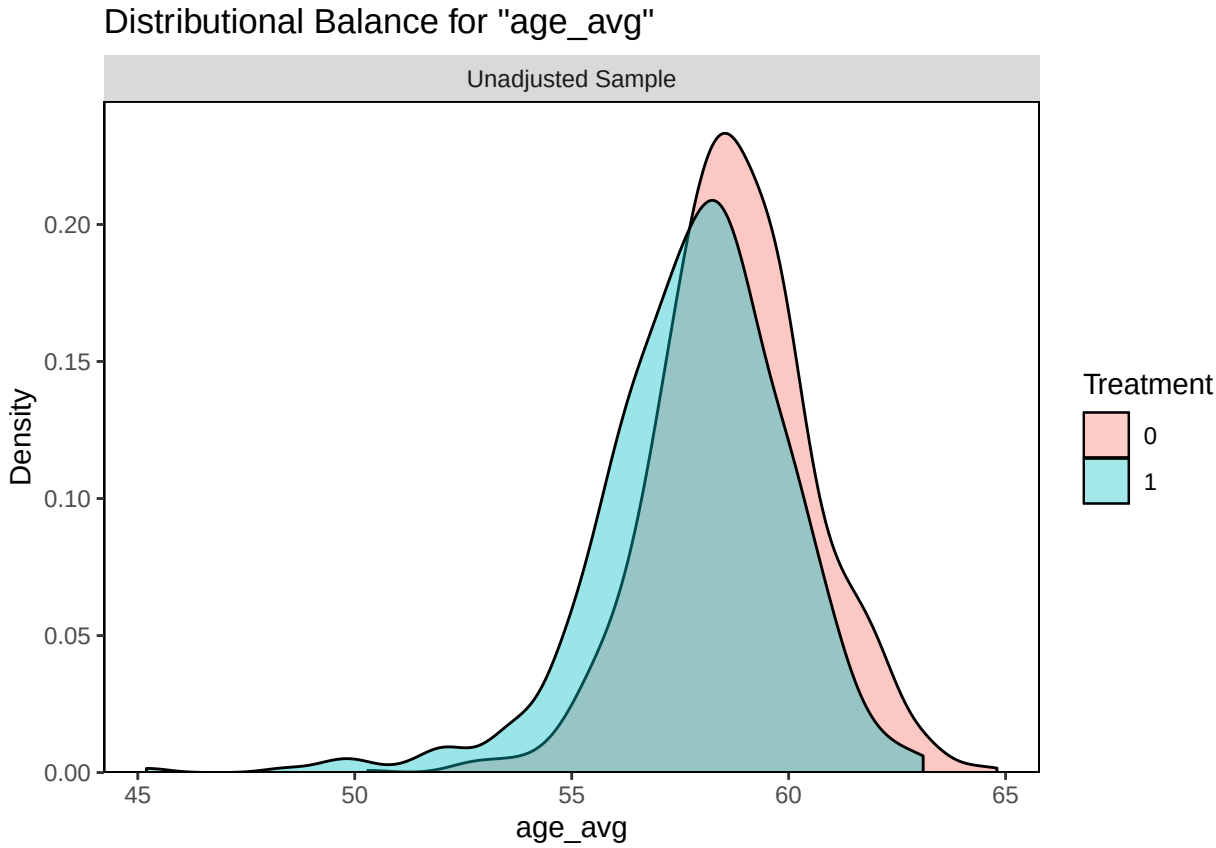
```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```r
library(sandwich)
```

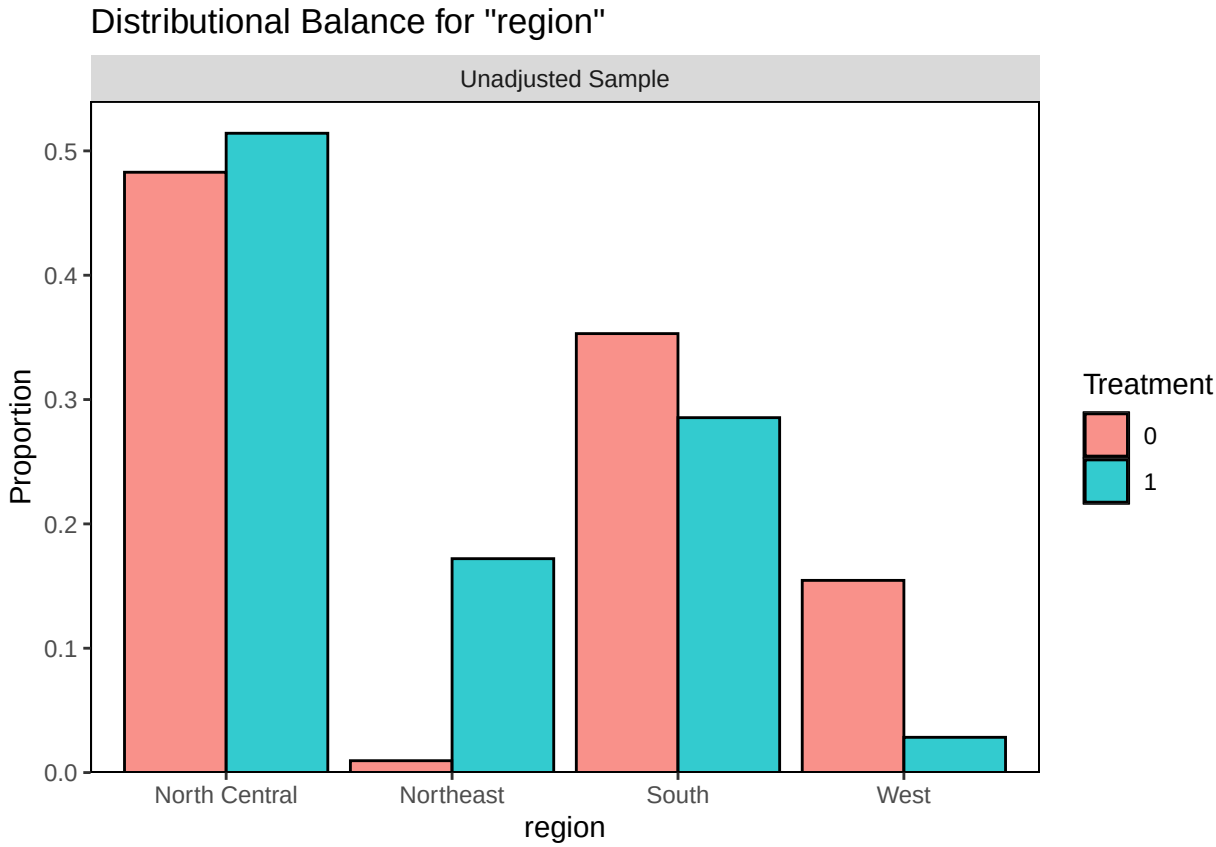
```r
farms_df <- read.csv("farms.csv")
head(farms_df)
```

```
##   total_yield cover_10 region total_avg age_avg experience_avg insurance_avg
## 1    61.33234        0  South     0.305    57.2           21.6     0.2543968
## 2    47.47099        1  South     0.208    61.2           24.9     0.6386207
## 3    46.27485        0  South     0.307    61.0           24.5     0.4223478
## 4    81.77405        0  South     0.254    58.8           23.9     1.0557846
## 5    81.04827        0  South     0.117    58.0           23.9     0.2556000
## 6    58.26087        0  South     0.292    62.5           23.6     0.6138043
##   easement_p conservation_till_avg fertilizer_per_area
## 1  1.8867925                   145            20.26741
## 2  1.5439430                   553            74.62687
## 3  0.8032129                    63            15.08367
## 4  1.1844332                   391            60.03353
## 5  0.5053341                    27            22.93760
## 6  2.3454158                   579            25.26148
```

```r
#balance plot for the average age
bal.plot(
  x = cover_10 ~ age_avg,
  data = farms_df,
  var.name = "age_avg"
)
```




```
#balance plot for the different regions
bal.plot(
  x = cover_10 ~ region,
  data = farms_df,
  var.name = "region"
)
```




```
#balance table to show SMD (Standardized Mean Differences) and Variance Ratios for all predictor variab
bal.tab(
  x = cover_10 ~ age_avg + region,
  data = farms_df,
  binary = "std",
  disp.v.ratio = TRUE
)
```

```
## Note: 's.d.denom' not specified; assuming pooled.
```

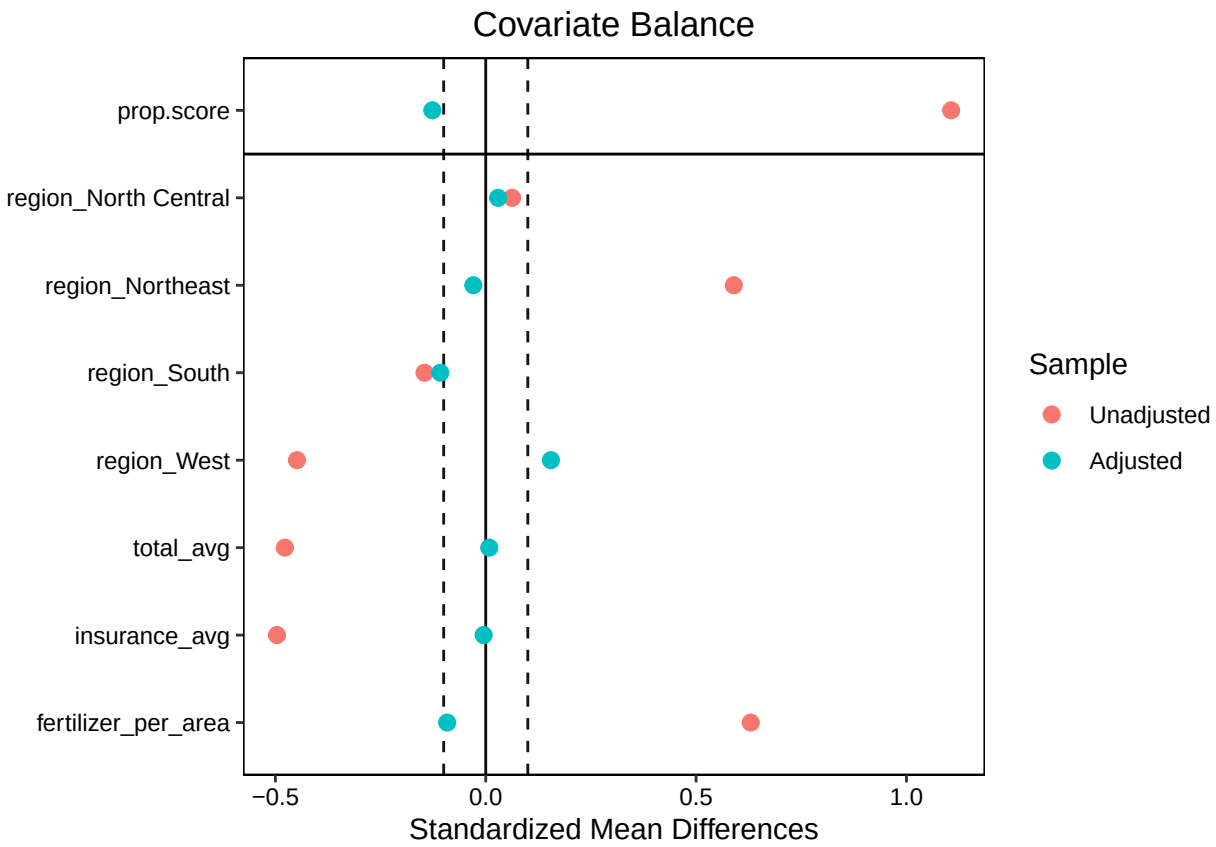
```
## Balance Measures
##                          Type Diff.Un V.Ratio.Un
## age_avg              Contin. -0.4668     1.4521
## region_North Central  Binary  0.0627          .
## region_Northeast      Binary  0.5896          .
## region_South          Binary -0.1454          .
## region_West           Binary -0.4488          .
##
## Sample sizes
##     Control Treated
## All    1048     529
```

- The SMDs are outside of the recommended -0.1 and 0.1 range.
- The variance ratio for age_avg is within the recommended range of 0.5 - 2.0

```
# Calculate IPTW weights with initial propensity score model
farm_iptw <- weightit(
  cover_10 ~ region + total_avg + insurance_avg + fertilizer_per_area,
  data = farms_df,
```

```
  estimand = "ATE",
  method = "ps"
)
```

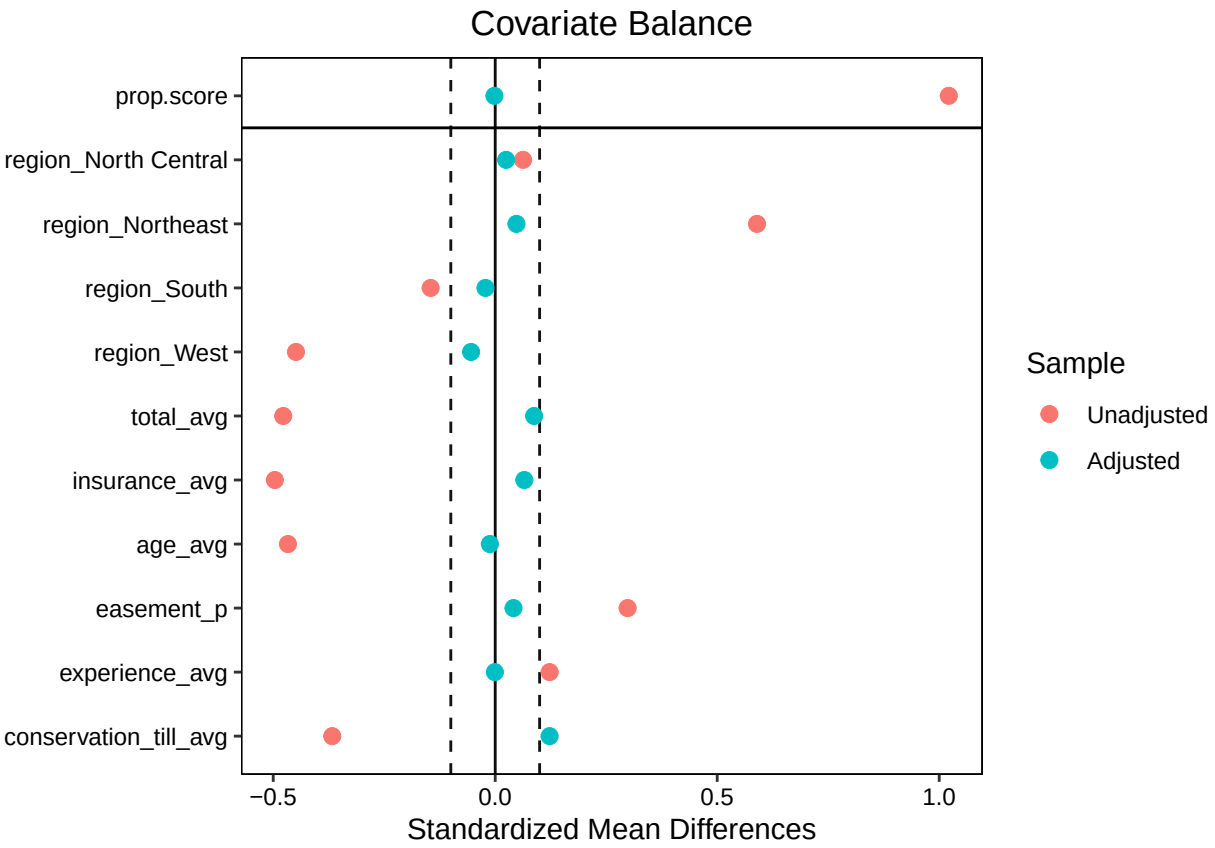
```
#plot love plot to evaluate SMD for farm_iptw before and after weighting
love.plot(
  x = farm_iptw,
  binary = "std",
  thresholds = c(m = 0.1)
)
```



Close after weighting but needs refinement.

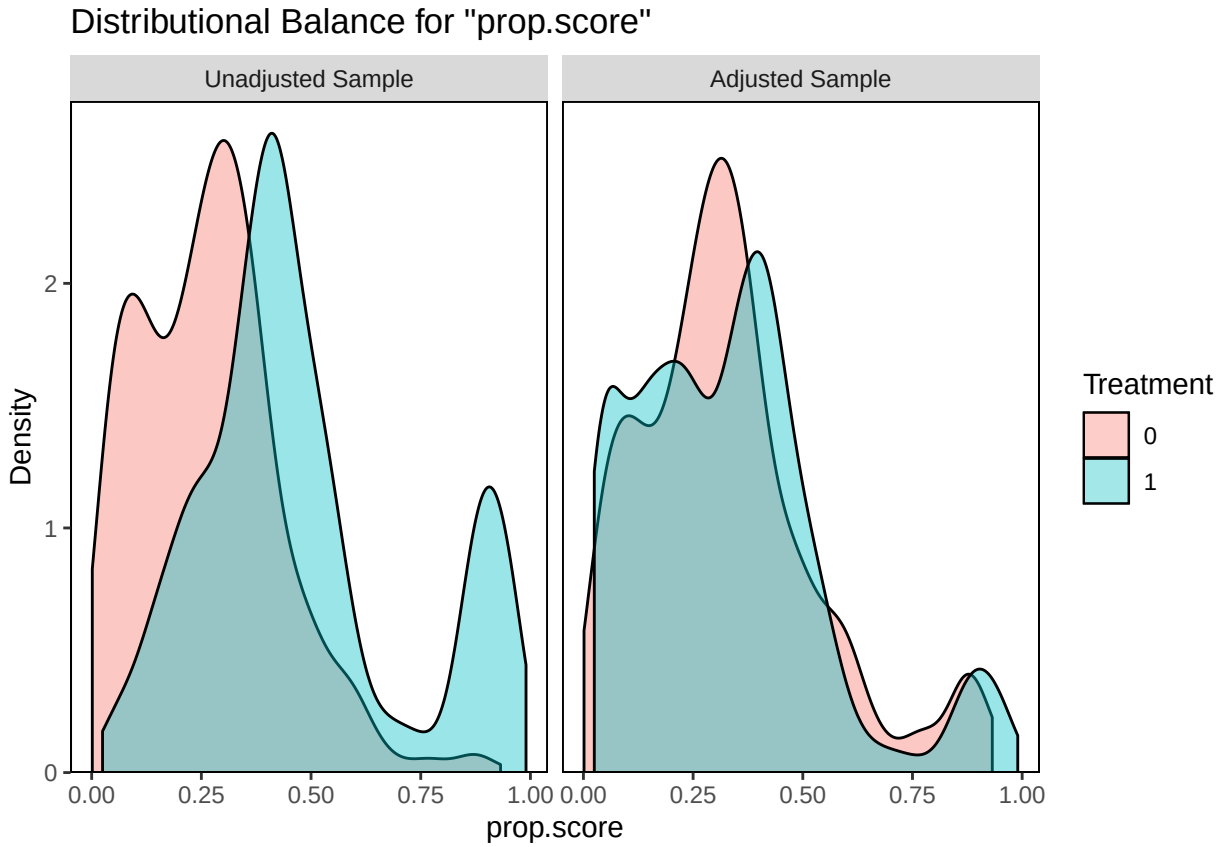
```
#create new propensity score model with new values
farm_iptw2 <- weightit(
  cover_10 ~ region + total_avg + insurance_avg + age_avg + easement_p + experience_avg + conservation_
  data = farms_df,
  estimand = "ATE",
  method = "ps"
)
```

```
#plot love plot showing SMD of new propensity score model
love.plot(
  x = farm_iptw2,
  binary = "std",
  thresholds = c(m = 0.1)
)
```



The SMD values are closer to zero than before, showing that this model is an improvement.

```
#plot bal plot to show propensity scores before and after weighting
bal.plot(
  x = farm_iptw2,
  var.name = "prop.score",
  which = "both"
)
```




```
#fit a regression model for total crop yield as the outcome, cover crop useage as the treatment and oth
yield_mod <- glm(
  total_yield ~ cover_10 + region + total_avg + insurance_avg + age_avg + easement_p + experience_avg +
  data = farms_df,
  weights = farm_iptw2$weights
)
```

With the regression model fitted, we now need robust standard errors

```
#estimate regression parameters for the weighted regression model
coeftest(
  yield_mod,
  vcov. = vcovHC
)
```

```
##
## z test of coefficients:
##
##                          Estimate  Std. Error z value  Pr(>|z|)
## (Intercept)           111.0182307  15.4101202  7.2042 5.837e-13 ***
## cover_10                3.5768404   1.0373046  3.4482 0.0005643 ***
## regionNortheast        -7.8566450   2.4221267 -3.2437 0.0011799 **
## regionSouth            -3.6146891   1.4750675 -2.4505 0.0142648 *
## regionWest             18.5398103   2.9171803  6.3554 2.079e-10 ***
## total_avg             -18.1552947   2.1255363 -8.5415 < 2.2e-16 ***
## insurance_avg           6.2900784   2.2013023  2.8574 0.0042708 **
## age_avg                -1.7556714   0.2890145 -6.0747 1.242e-09 ***
## easement_p              0.2464213   0.1659482  1.4849 0.1375627
```

```
## experience_avg          2.1238056   0.3191488  6.6546 2.841e-11 ***
## conservation_till_avg  -0.0048407   0.0016546 -2.9256 0.0034379 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The estimate of the ATE (Average Treatment Effect) for cover_10 (at least 10% of farms have cover crops) on total yield is 3.58. Meaning that for counties that have at least 10% of farms with cover crops, the yield increases by 3.58 units (bushels per acre).